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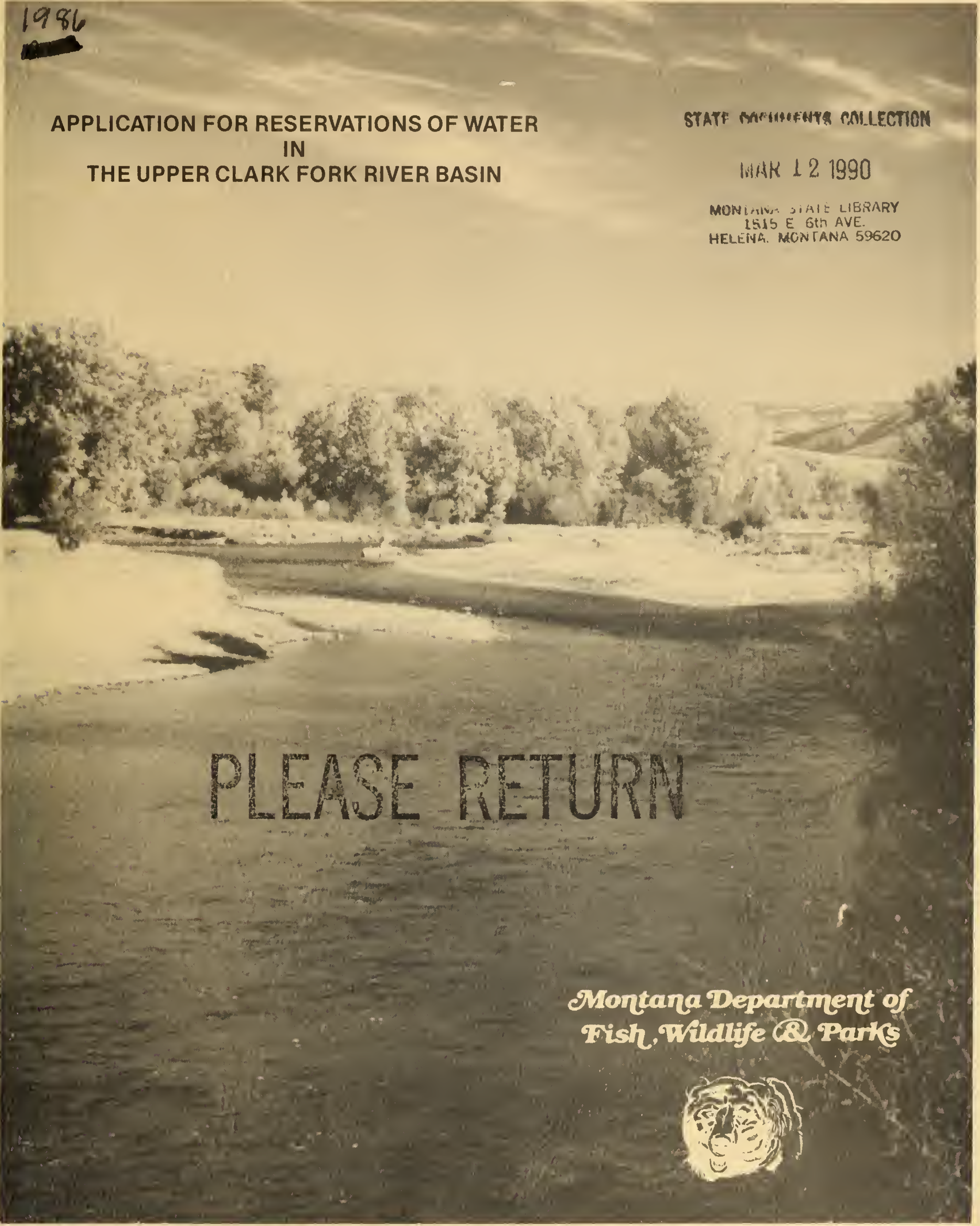

APPLICATION FOR RESERVATIONS OF WATER IN THE UPPER CLARK FORK RIVER BASIN

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APPLICATION FOR RESERVATIONS OF WATER
IN
THE UPPER CLARK FORK RIVER BASIN

Submitted by:

Montana Department of Fish, Wildlife & Parks
1420 East Sixth Ave.
Helena, Montana 59620

November, 1986

Form 610N9/74 Application No. 63302-7

STATE OF MONTANA
DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION

APPLICATION FOR RESERVATION OF WATER

Note: Pursuant to Section 89-890, R.C.M. 1947, only the state or any political subdivision or agency thereof, or the United States or any agency thereof, may apply to the board to reserve waters for existing or future beneficial uses, or to maintain a minimum flow, level, or quality of water throughout the year or at such periods or for such length of time as the board designates. Pursuant to Section 89-8-107, R.C.M. 1947, the United States or any agency thereof may not apply for a reservation of water in the Yellowstone River basin until the requirements of Section 89-8-105, R.C.M., are met.

(Please type or print in ink)

1. Name of applicant Montana Department of Fish, Wildlife and Parks

Mailing address 1420 East Sixth Avenue

City or town Helena State Montana Zip 59620

Home phone 444-3888 Other phone

2. Source of water supply Clark Fork River and selected tributaries above the mouth of the Blackfoot River

a tributary of

3. Use(s) to which reserved waters will be applied instream for fish, wildlife and recreation and the maintenance of water quality

4. Amount of water necessary for the reservation as per attached statement
(cubic feet per second and acre-feet per year)

5. Type of reservation:

a. Waters will be reserved in stream for beneficial use without diversion:
Yes XX No

b. Reservation requires construction of a storage or diversion facility to exercise the beneficial use:
Yes No XX

6. If a storage or diversion facility is necessary, the date by which reserved waters will be applied to a beneficial use is N/A
(month and year)

7. THE APPLICANT CERTIFIES THAT THE STATEMENTS APPEARING HEREIN ARE TO THE BEST OF HIS KNOWLEDGE TRUE AND CORRECT.

Ronald G. Marcoux
Signature of applicant

4/21/86
Date

(See reverse side for special instructions.)

TABLE OF CONTENTS

Page
Application for Reservation of Water (Form 610)............ i

List of Figures.................................... vi

List of Tables..................................... x

I. INTRODUCTION.................................... 1

II. THE PURPOSE OF THE RESERVATION.................. 3

III. THE NEED FOR THE RESERVATION.................... 3

IV. THE AMOUNT OF WATER NECESSARY FOR THE PURPOSE OF THE RESERVATION.................................... 4

V. THAT THE RESERVATION IS IN THE PUBLIC INTEREST...... 4

VI. SUPPORTING STATEMENTS............................ 5

- A. Statement of the Purpose of the Reservation.... 6
- B. Statement of the Need for the Reservation...... 11
- C. Statement of the Amount of Water Necessary for the Purpose of the Reservation............ 16
  - 1. Introduction.............................. 16
  - 2. Instream Flow Method...................... 17
  - 3. Clark Fork River Basin Description........ 23
  - 4. Upper Clark Fork River Basin Description.. 25
  - 5. Instream Flow Requests--Habitat Quality... 32
    - Clark Fork River - Reach #1.......... 32
    - Clark Fork River - Reach #2.......... 37
    - Clark Fork River - Reach #3.......... 41
    - Clark Fork River - Reach #4.......... 45
    - Warm Springs Creek Basin Description. 49
    - Warm Springs Creek - Reach #1........ 53
    - Warm Springs Creek - Reach #2........ 56

TABLE OF CONTENTS (Cont.)

Page

Barker Creek.......................... 60

Cable Creek........................... 63

Storm Lake Creek...................... 65

Twin Lakes Creek...................... 69

Lost Creek............................ 72

Racetrack Creek Basin Description.... 76

Racetrack Creek - Reach #1........... 77

Racetrack Creek - Reach #2........... 80

Dempsey Creek......................... 83

Little Blackfoot River Basin Description...................... 86

Little Blackfoot River - Reach #1.... 87

Little Blackfoot River - Reach #2.... 90

Snowshoe Creek........................ 93

Dog Creek............................. 96

Gold Creek............................ 99

Flint Creek Basin Description........ 102

Flint Creek - Reach #1............... 103

Flint Creek - Reach #2............... 106

Boulder Creek......................... 109

North Fork of Flint Creek............ 112

Stuart Mill Creek..................... 115

Harvey Creek.......................... 117

6. Water Quality Considerations............. 120

a. Introduction.......................... 120

b. Water Quality Standards and Criteria. 121

TABLE OF CONTENTS (Cont.)

Page

c. Metals in the Clark Fork Drainage.... 123

d. Dissolved Oxygen.................... 142

e. Water Temperature................... 142

f. Relationship of Flow to Water Quality........................... 144

g. Implications of Water Quality Flow Requests............................ 145

h. Water Quality Flow Requests.......... 146

7. Water Availability........................ 148

D. Statement that the Reservation is in the Public Interest.. 163

1. Introduction.............................. 163

2. Agriculture............................... 164

a. Existing Situation................... 164

b. Irrigated Lands..................... 164

c. Potentially Irrigable Lands.......... 166

d. Benefits............................ 168

e. Impacts............................. 169

3. Industry.................................. 170

a. Existing Situation................... 170

b. Benefits............................ 172

c. Impacts............................. 173

4. Municipalities............................ 174

a. Existing Situation................... 174

b. Benefits............................ 175

c. Impacts............................. 176

5. Fish, Wildlife and Recreation............ 176

TABLE OF CONTENTS (Cont.)

Page

a. Existing Situation.................... 176

b. Benefits - Social.................... 180

c. Benefits - Economic.................. 182

d. Impacts.............................. 188

e. Instream Flow Requirements for Boating.............................. 188

6. Alternative Actions...................... 192

7. State and Federal Legislation and Policies which Support the Reservation............. 197

a. State of Montana Legislation and Policies............................. 199

b. Federal Legislation.................. 203

VII. SUMMARY.. 208

VIII. LITERATURE CITED.............................. 211

IX. ADDENDA... 219

Addendum A - Water Availability Data.............
Addendum B - Irrigated Land Assessment of the upper Clark Fork River Drainage...
Addendum C - Leathe, S.A. and F.A. Nelson. 1986. A literature evaluation of Montana's wetted perimeter inflection point method for deriving instream flow recommendations..................
Addendum D - Flow duration hydrograph............
Addendum E1 - Total cash revenue from livestock and livestock products in Deerlodge, Granite and Powell counties.......
Addendum E2 - Total cash revenue from crops in Deerlodge, Granite and Powell counties.........................
Addendum F1 - Invalid objection ruling............
Addendum F2 - Lack of standing chronology.........
Addendum G - Irrigated and non-irrigated Cropland in Deerlodge, Granite and Powell counties.........................
Addendum H - Contributors........................

LIST OF FIGURES

Figure | Page
1 Clark Fork of the Columbia River basin (map)...... 2
2 Trout populations in the upper Clark Fork River, 1978-1986.................................... 8
3 The wetted perimeter in a channel cross-section... 19
4 An example of a relationship between wetted perimeter and flow for a stream riffle cross-section showing upper and lower inflection points and their relationship to fish food production.... 20
5 Upper Clark Fork of the Columbia River Basin (map) 26
6 The relationship between wetted perimeter and flow from a composite of 5 riffle/run cross-sections in the Clark Fork River near Deer Lodge.......... 36
7 The relationship between wetted perimeter and flow from a composite of 3 riffle cross-sections in the Clark Fork River near Gold Creek................. 40
8 The relationship between wetted perimeter and flow from a composite of 3 riffle cross-sections in the Clark Fork River near Bearmouth.................. 44
9 The relationship between wetted perimeter and flow from a composite of 3 riffle cross-sections in the Clark Fork River near Turah...................... 48
10 Warm Springs Creek Drainage and Flint Creek (map). 50
11 The relationship between wetted perimeter and flow from a composite of 3 riffle cross-sections in Warm Springs Creek above Meyers Dam................... 55
12 The relationship between wetted perimeter and flow from a composite of 3 riffle cross-sections in Warm Springs Creek near its mouth.................... 59
13 The relationship between wetted perimeter and flow from a composite of 2 riffle cross-sections in Barker Creek..................................... 62
14 The relationship between wetted perimeter and flow from a composite of 2 riffle cross-sections in Storm Lake Creek................................. 68

LIST OF FIGURES (cont.)

Figure Page

15 The relationship between wetted perimeter and flow from a composite of 3 riffle cross-sections in Twin Lakes Creek.......................... 71

16 The relationship between wetted perimeter and flow from a composite of 3 riffle cross-sections in Lost Creek.................................... 75

17 The relationship between wetted perimeter and flow from a composite of 3 riffle cross-sections in Racetrack Creek near the Deerlodge National Forest boundary................................. 79

18 The relationship between wetted perimeter and flow from a composite of 3 riffle cross-sections in Racetrack Creek near its mouth................... 82

19 The relationship between wetted perimeter and flow from a composite of 2 riffle cross-sections in Dempsey Creek................................ 85

20 The relationship between wetted perimeter and flow from a composite of 3 riffle cross-sections in the Little Blackfoot River above the confluence of Dog Creek.. 89

21 The relationship between wetted perimeter and flow from a composite of 3 riffle cross-sections in the Little Blackfoot River near its mouth............ 92

22 The relationship between wetted perimeter and flow from a composite of 3 riffle cross-sections in Showshoe Creek............................... 95

23 The relationship between wetted perimeter and flow from a composite of 3 riffle cross-sections in Dog Creek.. 98

24 The relationship between wetted perimeter and flow from a composite of 3 riffle cross-sections in Gold Creek.. 101

25 The relationship between wetted perimeter and flow from a composite of 3 riffle cross-sections in Flint Creek above the confluence of Boulder Creek. 105

26 The relationship between wetted perimeter and flow from a composite of 3 riffle cross-sections in Flint Creek near its mouth...................... 107

LIST OF FIGURES (cont.)

Figure Page

27 The relationship between wetted perimeter and flow from a composite of 5 riffle cross-sections in Boulder Creek.. 111

28 The relationship between wetted perimeter and flow from a composite of 3 riffle cross-sections in the North Fork of Flint Creek......................... 114

29 The relationship between wetted perimeter and flow from a composite of 3 riffle cross-sections in Harvey Creek... 119

30 Upper Clark Fork river mining and smelter sites and mine waste treatment facilities (map)......... 124

31 Upper Clark Fork River drainage showing locations where copper concentrations and flows were measured during 1984.............................. 128

32 Copper concentrations and flows in the Mill-Willow Bypass, Warm Springs Pond-2 discharge, and Warm Springs Creek during 1983......................... 130

33 Copper concentrations and flows in the Mill-Willow Bypass, Warm Springs Pond-2 discharge, and Warm Springs Creek between March 29 and April 16, 1984. 131

34 Copper concentrations and flows at three Clark Fork River locations during 1983....................... 132

35 Copper concentrations and flows at four Clark Fork River locations between April 3 and July 16, 1984. 133

36 Copper concentrations and flows at four Clark Fork River locations between April 3 and July 16, 1984. 134

37 Comparison of copper concentrations at stations above and below the Little Blackfoot River (1984) demonstrating that dilution from the Little Blackfoot lowers copper concentrations in the Clark Fork River.................................... 136

38 Comparison of copper concentrations at stations above and below Rock Creek (1984) demonstrating that dilution from Rock Creek lowers copper concentrations in the Clark Fork River........... 137

LIST OF FIGURES (cont.)

Figure Page

39 Copper loading in the Mill-Willow Bypass, Warm Springs Pond-2 discharge, and Warm Springs Creek during 1983.................................... 138

40 Copper loading in the Mill-Willow Bypass, Warm Springs Pond-2 discharge, and Warm Springs Creek between April 10 and July 16, 1984................ 139

41 Copper loading at three Clark Fork River locations during 1983.................................... 140

42 Copper loading at five Clark Fork River locations between April 10 and July 16, 1984................ 141

43 Streamflow of Racetrack Creek upstream from all irrigation diversions for a 32-year period of record.. 149(a)

44 Streamflow of the Clark Fork River at Gold Creek for a 32-year period of record.................. 149(b)

45 Historic (depleted) and simulated virgin flows in the Clark Fork River at Deerlodge................ 150

46 Streamflows of Warm Springs Creek, 1985 Water Year... 157

47 Streamflows of the Clark Fork River at Deerlodge, 1985 water year................................ 158

48 Streamflows of the Clark Fork River at Gold Creek, 1985 Water Year................................ 160

49 Streamflows of the Clark Fork River near Clinton, 1985 Water Year................................ 161

50 Streamflows of the Little Blackfoot River near Garrison, 1985 Water Year....................... 162

51 Total income from crops and livestock in Deer Lodge, Granite, and Powell counties (adjusted to 1984 dollars)................................... 165

52 Irrigated and non-irrigated land in Deer Lodge, Granite, and Powell counties..................... 167

LIST OF TABLES

Table Page

1 Water permit applications on the Clark Fork River upstream from Milltown Dam that were objected to by the DFWP since June, 1982..................... 11

2 Principal U.S. Geological gaging stations, drainage areas, and stream discharges for their periods of record--Clark Fork River basin......... 24

3 Estimated numbers of brown trout per mile in the pH Shack, Sager Lane, and Williams-Tavenner sections, 1972-1986.. 34

4 Estimated numbers of all trout species per mile at the Phosphate, Gold Creek and Drummond sections... 38

5 Estimated numbers of all trout species per mile in the Bearmouth and Bonita sections................. 42

6 Estimated numbers of all trout species per mile in the Turah section................................ 46

7 Percentage of water samples which exceeded B-1 acute toxicity criteria for copper in the Clark Fork River between Warm Springs Creek and the Little Blackfoot River, 1975-1983................. 126

8 Percentage of water samples which exceeded B-1 acute toxicity criteria for copper in the Clark Fork River between the Little Blackfoot River and Milltown Dam, 1975-1983........................... 127

9 Locations and dates of dissolved oxygen measurements in the Clark Fork River when concentrations below 7.0 mg/l were recorded....... 143

10 Number of days in June, July and August (1977-82) when median daily temperature exceeded 66°F at several locations along the Clark Fork River...... 143

11 Summary of instream flow requests (cfs)........... 147

12 Water available in excess of two instream flow levels at a 20th percentile exceedance flow for reaches of the mainstem Clark Fork River.......... 153

13 Water available in excess of two instream flow levels at a 40th percentile exceedance flow for reaches of the mainstem Clark Fork River.......... 154

LIST OF TABLES (cont.)

Table Page

14 Water available in excess of two instream flow levels at a 60th percentile exceedance flow for reaches of the mainstem Clark Fork River.......... 155

15 Water available in excess of two instream flow levels at an 80th percentile exceedance flow for reaches of the mainstem Clark Fork River.......... 156

16 Montana wastewater discharge permits in the Clark Fork River basin.................................. 171

17 Populations of municipalities in the upper Clark Fork basin.. 176

18 Width and depth characteristics relating to boating on Reaches 1, 2, 3 and 4 of the upper Clark Fork River at high and low inflection point flows.. 191

19 Width characteristics of cross-sections in reaches 1, 2, 3 and 4 of the upper Clark Fork River at high and low inflection point flows............... 192

20 Instream flows requested and average annual flow of record (where available) for the upper Clark Fork River and tributary streams.................. 210

I.

INTRODUCTION

Fish, wildlife, and outdoor recreation resources are important to human well-being and must be preserved for the use and enjoyment of current and future generations. These resources are owned by the people of the state and must be managed for the best public interest.

The Department of Fish, Wildlife and Parks (DFWP) has a two-fold responsibility: (1) to protect and enhance the abundant and diverse fish, wildlife, and recreational resources, and (2) to provide optimum opportunities for diverse outdoor recreation that are commensurate with resource preservation.

Fish and wildlife populations and their habitats are inseparable. Therefore, preservation of fish and wildlife populations is necessarily dependent upon preservation of their habitat and all habitat components. The habitat components for cold-water trout streams and rivers are: (1) the physical streambed and banks, (2) the quality of the water, and (3) the quantity of the water.

Protection of the physical stream bed and banks is provided by the Stream Protection Act (87-5-501, MCA) and the Natural Streambed and Land Preservation Act of 1975 (75-7-101, MCA). The prevention, abatement, and control of pollution in state waters is the responsibility of the Montana Department of Health and Environmental Sciences through 75-5-211, MCA. The 1973 Water Use Act provides the opportunity for the state or any political subdivision or agency thereof or the United States to apply to the Board of Natural Resources and Conservation to reserve waters for existing or future beneficial uses or to maintain a minimum flow, level or quality of water (Section 85-2-316, MCA). A water reservation for a minimum instream flow would serve to protect a vital component of stream fishery habitat.

Pursuant to Section 85-2-316, MCA, and Article II of the Constitution of the state of Montana which establishes that a clean and healthful environment is an inalienable right of Montana citizens, the Montana Department of Fish, Wildlife and Parks hereby respectfully files application for reservation of water in the upper portion of the Clark Fork of the Columbia River basin.

The Clark Fork River has its headwaters at the confluence of Silver Bow and Warm Springs creeks near Anaconda, Montana and flows for approximately 350 miles before terminating in Lake Pend Oreille, Idaho (Figure 1). This application requests reservation of water in the Clark Fork River and within certain of its tributaries located within the river basin from its headwaters near the town of Anaconda to Milltown Dam near the town of Bonner.

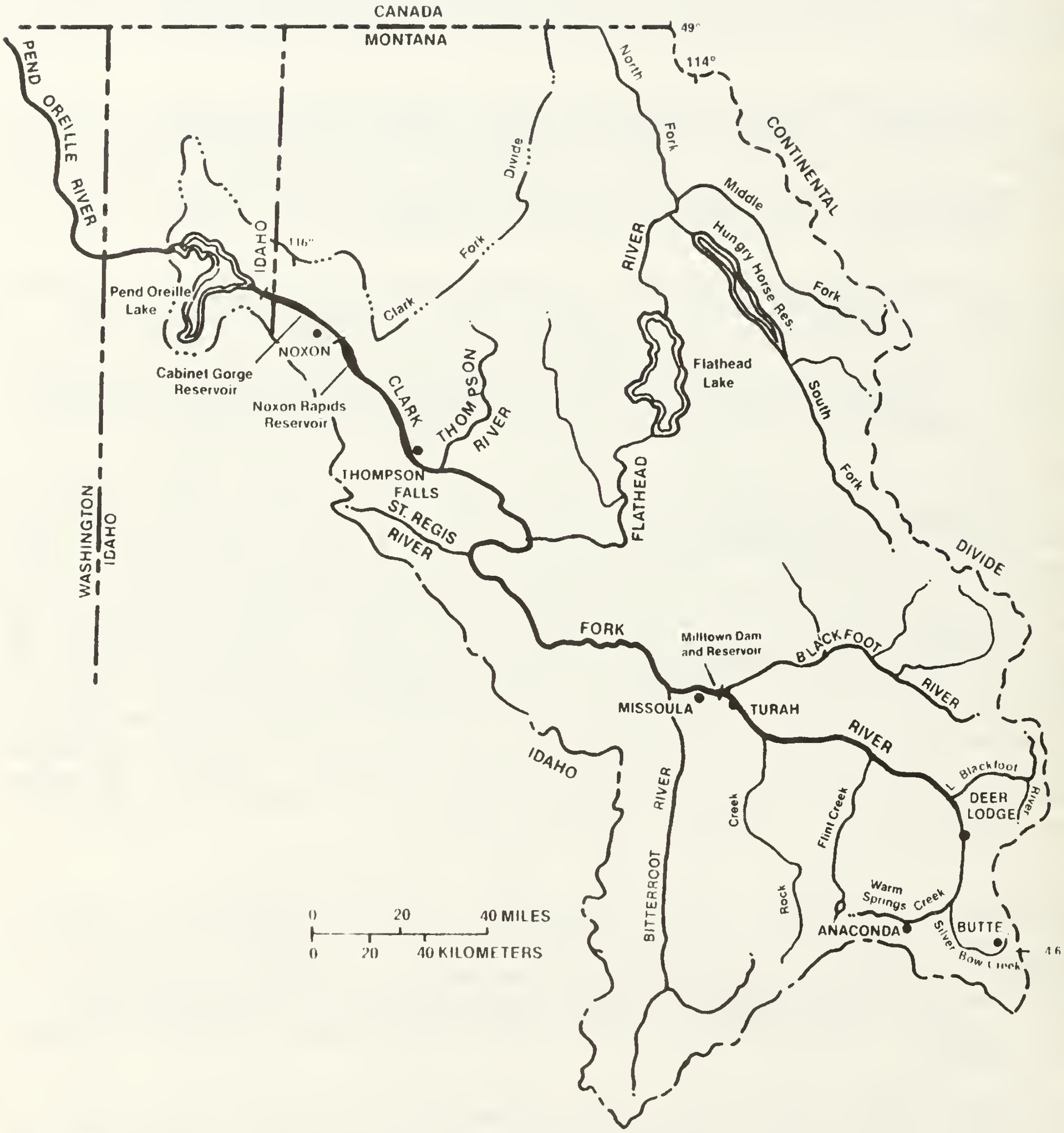


Figure 1. Clark Fork of the Columbia River basin.

II.

THE PURPOSE OF THE RESERVATION

The purpose of the reservation herein applied for is to reserve waters, and flows thereof, for existing and future beneficial uses and to maintain a minimum flow, level and quality of water during such periods throughout each year in order to attain and serve such existing and future beneficial uses as follows:

(1) for the benefit of the public for fish and wildlife uses;
(2) for the benefit of the public for recreational uses;
(3) for the benefit of the public to prevent further deterioration of the quality of water in the Clark Fork River; and
(4) to protect the investment being made in pollution abatement and containment throughout the basin.

The attainment and service of such uses are to:

(1) provide fish and wildlife habitat sufficient to accommodate a diversity of species now comprising or capable of comprising this natural resource at levels comparable to, or better than, the existing levels;
(2) preserve the opportunity to enhance fish populations up to the normal carrying capacity of the existing habitat once water quality is improved;
(3) contribute to, and maintain a clean, healthful and desirable environment;
(4) sustain adequate levels of water quality; and
(5) honor and support all existing water use rights.

III.

THE NEED FOR THE RESERVATION

A water right for instream beneficial use for fish and wildlife, and recreational uses may be obtained, under applicable statutes and rules, only by application for reservation and not by petition or application for permit. Without this reservation, the beneficial uses of fish, wildlife and recreation provided by Montana law cannot be met or maintained.

Existing water rights in the river basin will at all times be honored. If the reservations here requested are not granted and approved, any waters available over and above such existing rights will be vulnerable to future appropriations by permit. If these future appropriations are allowed to be executed in advance of, or without, the reservations here requested being established, the fish and wildlife resources will be permanently deprived of the waters so necessary for their healthy survival. It is readily apparent when realistically considered, that under our current laws and regulations, waters once allowed to be appropriated might well never again be available to reservation for fish and wildlife purposes. The need for an adequate reservation now is thus dictated.

The documentation for this need is found in the "Statement of the Need for the Reservation" and other statements attached to this application.

IV.

THE AMOUNT OF WATER NECESSARY FOR THE PURPOSE OF THE RESERVATION

The Montana Department of Fish, Wildlife and Parks, an agency of the state of Montana, requests and applies for an instream reservation of water and flows thereof during each year hereafter in the Clark Fork basin of the Columbia River, including the Clark Fork River from its confluence with Warm Springs Creek near the town of Anaconda, to Milltown Dam near the town of Bonner, and certain tributaries of the river, in amounts as indicated by stream or stream reach, and for periods indicated for each of the respective streams set forth in the "Statement on Amount of Water Necessary for the Purpose of the Reservation" attached hereto and hereby made a part of this application.

V.

THAT THE RESERVATION IS IN THE PUBLIC INTEREST

This reservation of water is in the public interest. The public benefits which will occur from the reservation are:

(1) continued perpetuation of the fish and wildlife resources whose very existence is in the public interest;
(2) prevention of the gradual depletion of streamflows currently enjoyed by the public for recreational uses;
(3) continued perpetuation of the fish and wildlife resources for current and future utilization by the public;
(4) preservation of the opportunity for a substantially improved aquatic ecosystem;
(5) maintenance of water quality which contributes to a clean, healthful environment for the citizens of the state and the nation; and
(6) contribution to the protection of and continued utilization of existing water rights.

The explanation of these public benefits, by economic and environmental beneficial and adverse effects, is provided in the "Statement that the Reservation is in the Public Interest."

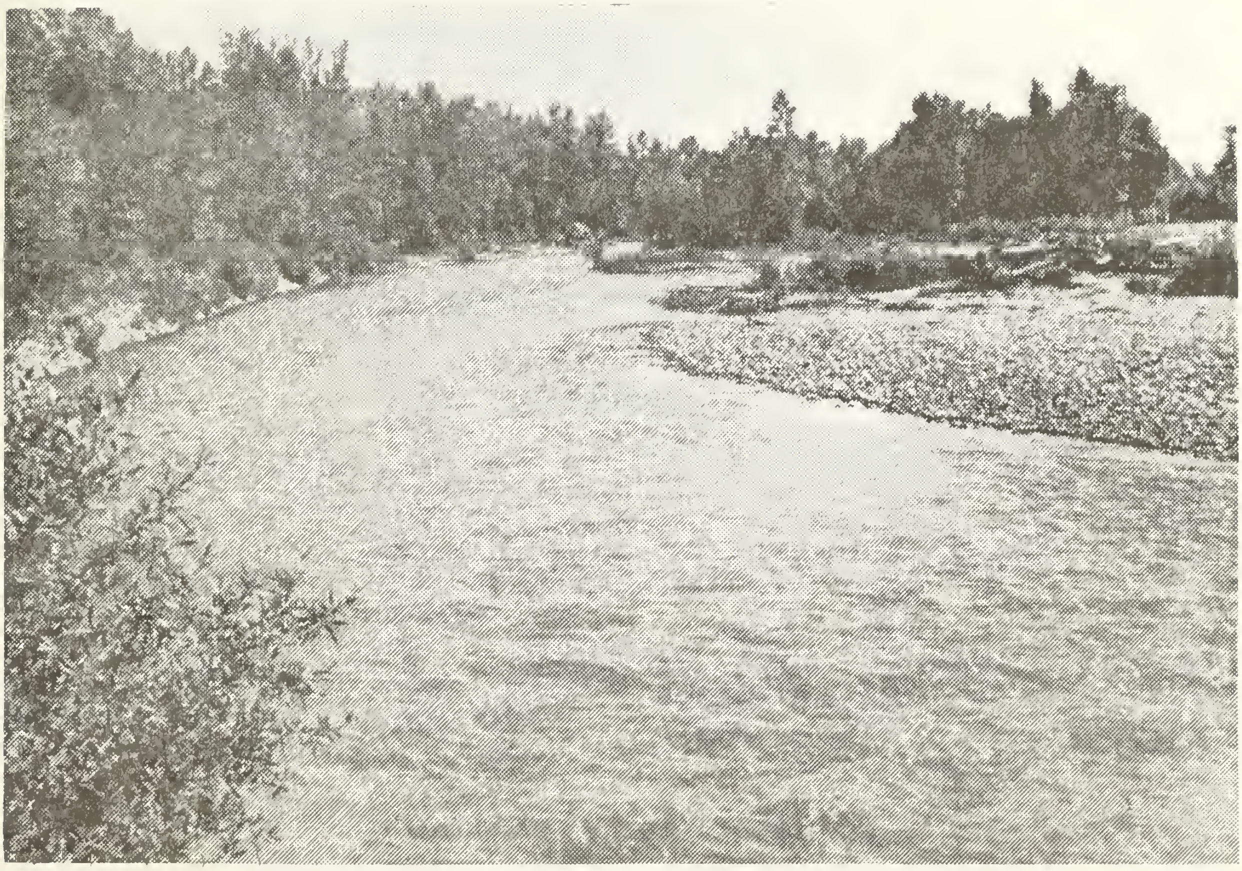
Included therein is reference to state and federal legislation or policies which support fish and wildlife and recreational uses.

VI.

SUPPORTING STATEMENTS

There are attached hereto, and made a part hereof, statements on the purpose of, the need for, amount of, and public interest of this requested reservation of water, including a summary statement. These statements and their attachments are presented in support of this application for reservation of water and to meet the requirements of the Montana Water Use Act and applicable rules thereunder in establishment of a reservation of water and flows thereof for fish and wildlife and recreational uses.

STATEMENT OF THE PURPOSE OF THE RESERVATION



A. STATEMENT OF THE PURPOSE OF THE RESERVATION

The purpose of the reservation herein applied for is to reserve waters, and flows thereof, for existing and future beneficial uses and to maintain a minimum flow, level and quality of water during such periods throughout each year in order to attain and serve such existing and future beneficial uses as follows:

(1) for the benefit of the public for fish and wildlife uses;
(2) for the benefit of the public for recreational uses;
(3) for the benefit of the public to prevent further deterioration of the quality of water in the Clark Fork River; and
(4) to protect the investment being made in pollution abatement and containment throughout the basin.

The upper Clark Fork River and its major tributaries contain moderate to excellent fish populations and support substantial recreational use. Fishing is the activity most often engaged in by recreationists and fishing pressure is closely correlated to the quality of fish populations in various reaches. Reaches of the Clark Fork River with the best fish populations have the highest fishing pressure and overall recreational use (Hagmann 1979).

The Clark Fork drainage, particularly the tributaries, supports breeding populations of two fishes listed by MDFWP and the Montana Chapter of the American Fisheries Society as Fishes of Special Concern (Holton 1986, Liknes 1984). Westslope cutthroat and bull trout are native fishes which are of special concern because they have been eliminated or severely reduced in numbers over much of their former range. Both species depend on relatively pristine habitat and low levels of competition with non-native fishes for survival.

Montana's streams were first classified for their resource values in 1959 with publication of a Montana stream classification map (Stream Classification Committee 1959). This map classified the Clark Fork River from Warm Springs Creek to the Little Blackfoot River as Class 5--the lowest classification possible. From the Little Blackfoot River to Milltown Dam the river was Class 4. These low classifications were due mostly to river pollution from headwater mining activities. Also, about this same time, the river from Warm Springs Creek to the Little Blackfoot River was classified by the Montana Water Pollution Control Council as a Class E stream, suitable only for agricultural and industrial use (Board of Health 1960).

Waste treatment improvements by the Anaconda Minerals Company (AMC) in the 1960's resulted in a steady improvement in water quality and the fishery of the stream. This has been reflected in the upgrading of its classification. The 1986 Montana Stream

Fisheries Assessment (DFWP 1986) classifies the reach from Warm Springs Creek to Dempsey Creek as Class II; from Dempsey Creek to Rock Creek as Class III; and from Rock Creek to Milltown Dam again as Class II. A Class II stream is one which contains high value fishery resources.

Both the fish populations themselves and the recent stream classification reflect the resilience of biological populations. The fish community's response to improved habitat conditions--in this case water quality--is quite evident. As late as 1972, fish were largely absent from the headwaters to Deerlodge, a condition probably common since before the turn of the century. Today the stream supports a fishery for trophy-sized trout which is managed by special fishing regulations.

The water quality classification of the Clark Fork has also been upgraded since its 1958 inception. The river is currently classified to consider growth and propagation of salmonid fish (trout) and associated aquatic life to be important. Again, it is the improved water quality which has enabled this upgraded classification.

The improvements in pollution control measures in the Butte/Anaconda areas are the reasons for the significantly increased fish populations in several miles of the upper river immediately below Warm Springs Creek. Good physical habitat (which has always been there) combined with improved water quality has resulted in fish populations of more than 2,000 brown trout per mile, a density considered excellent for this size stream (Figure 2).

Trout in downstream reaches, however, are noticeably less abundant (see Figure 2), ranging from a maximum of less than 500 fish per mile from Deer Lodge to near Drummond. Trout densities are lowest (up to 120 fish per mile) from near Bearmouth to the confluence with Rock Creek. Below Rock Creek, the Clark Fork benefits from the clean, colder waters of Rock Creek and supports maximum fish densities of over 500 fish per mile.

Lower density fish populations in downstream areas are the result of poor habitat conditions caused by stream channelization, dewatering and chemical pollutants. The latter is believed most responsible for limiting the fishery. These pollutants are the result of a century of untreated mining wastes entering the upper Clark Fork River, and their resultant deposition in the river and along its flood plain.

A recreational use survey was conducted on the upper Clark Fork River and its major tributaries to determine the extent and characteristics of recreational use in the upper basin (Hagmann 1979). The survey was conducted in 1978-1979 in the upper Clark Fork River Basin above Milltown Dam, including the major tributaries of Warm Springs Creek, Little Blackfoot River, Flint Creek and Rock Creek. Rock Creek is not included in the current

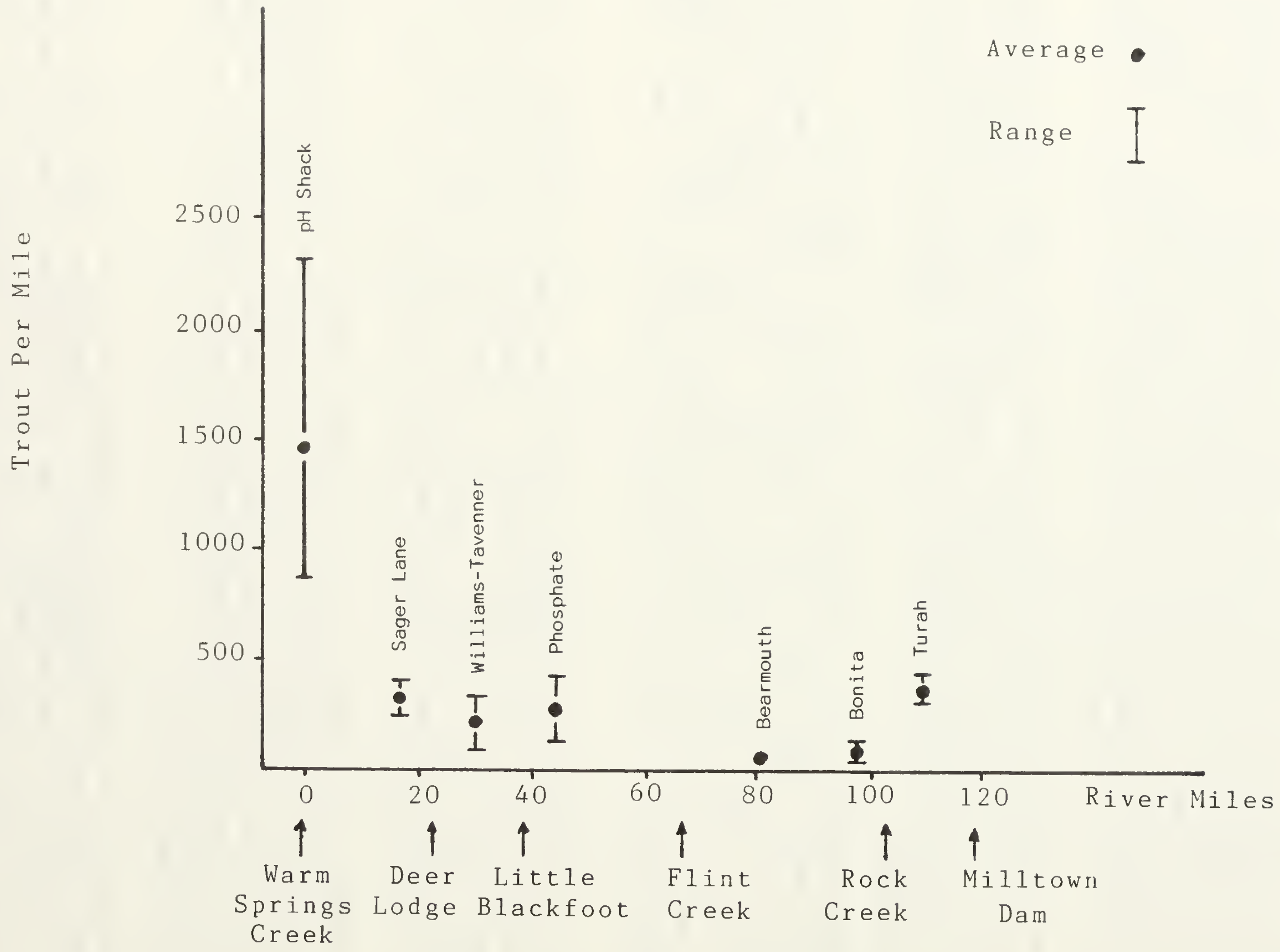


Figure 2. Trout populations in the upper Clark Fork River, 1978-1986.

reservation application, however, data from the survey are presented for comparative purposes.

During the survey period (June 1, 1978 through May 31, 1979), an estimated 102,631 recreational visits occurred on the upper Clark Fork and its selected tributaries. These figures do not include winter recreational use on Flint Creek, the Little Blackfoot River and Warm Springs Creek, or any recreational use (summer or winter) on Rock Creek. During this same study period, Rock Creek itself received an estimated 167,000 recreation visits between May 1 and November 30. The figures also do not include any recreational use on the other tributary streams presented in this application.

A majority of the recreational visits on the Clark Fork and tributaries occurred on its tributaries. Fishing was the activity most often engaged in by recreationists in the study area. Summer recreational use on the mainstem Clark Fork was estimated at 26,647 recreational visits. Winter use on the mainstem was estimated at 14,538 visits. Winter use was concentrated above Deer Lodge during the waterfowl hunting season and between Beavertail and Drummond during the winter whitefishing season. From March through June, trout fishing was the major use and was concentrated between Schwartz Creek and Milltown and between Warm Springs and Deerlodge.

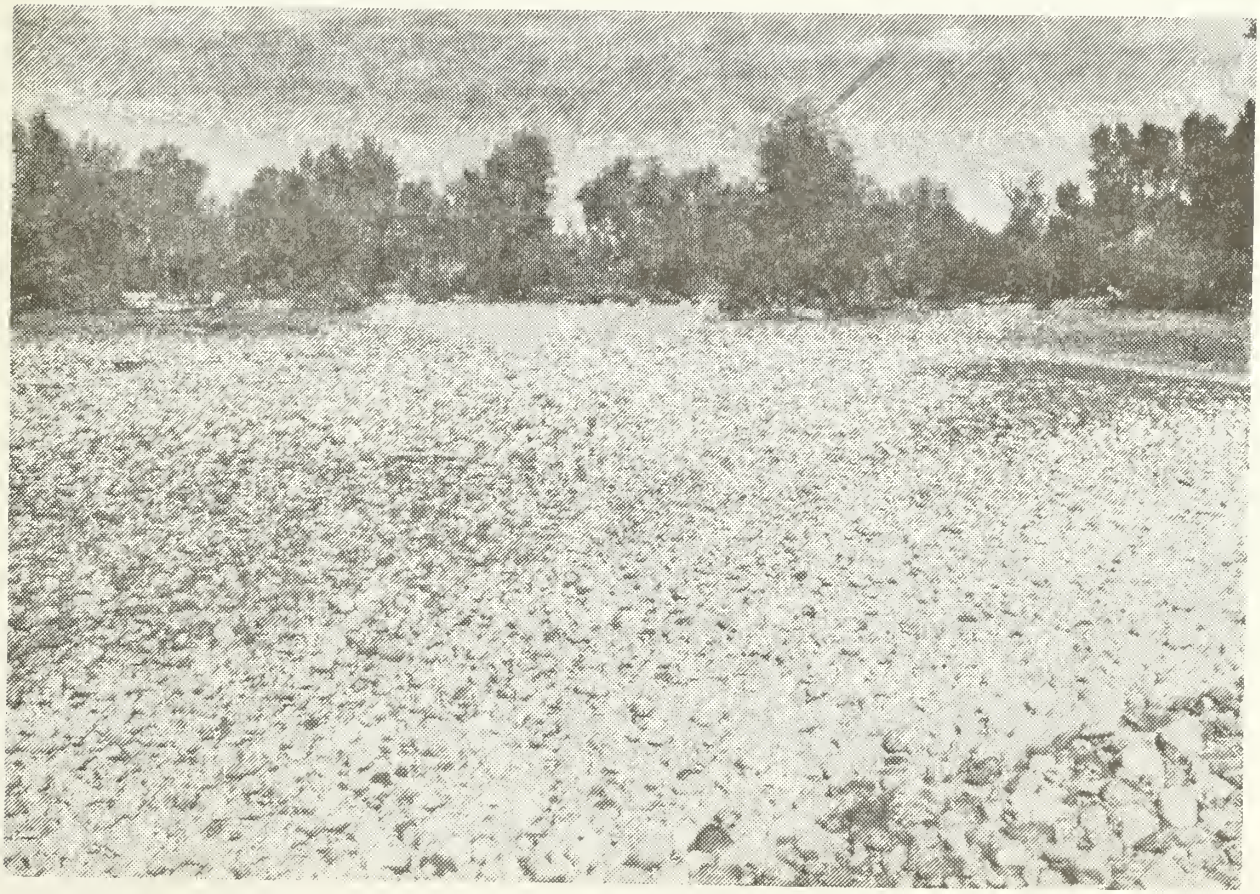
Seventy (70) percent of all the recreationists on the Clark Fork and its tributaries are Montanans, many of whom utilize the Clark Fork as their exclusive source of river-based recreation. If sufficient instream flows are not maintained to sustain the various recreational uses, recreational use would probably be displaced to other streams in the area. Shifts in recreational use from the Clark Fork to such rivers as the Blackfoot or the Bitterroot would impact the recreational quality of those rivers, which already receive substantial recreation use.

It has been demonstrated that the potential exists for the Clark Fork River to produce good to excellent fish populations (Knudson 1984). That potential is not realized in all reaches. Reduced populations are believed to be caused by high concentration of metals in the river which originate from erosion of mine tailings. Current efforts to develop a reclamation plan for the Clark Fork basin (Johnson and Knudson 1985; Multi-Tech 1986) provide the opportunity to develop a quality trout fishery. This reservation application is designed to maintain streamflows which will protect existing fish populations as well as provide flow conditions which will allow for their expansion after reclamation efforts are implemented.

Granting the requested instream flow reservations will:

(1) provide fish and wildlife habitat sufficient to perpetuate the species comprising this natural resource at levels comparable to current existing levels and preserve the opportunity to enhance fish populations to the normal carrying capacity of the existing habitat as water quality problems are lessened;
(2) contribute to, and maintain a clean, healthful and desirable environment;
(3) sustain adequate levels of water quality; and
(4) honor and support all existing water use rights.

STATEMENT OF THE NEED FOR THE RESERVATION



B. STATEMENT OF THE NEED FOR THE RESERVATION

A water right for instream beneficial use for fish and wildlife, and recreational uses may be obtained, under applicable statutes and regulation only by application for reservation and not by petition or application for permit.

Since the implementation of the 1973 Water Use Act, the DFWP has objected to the issuance of new water use permits where such permits would adversely affect instream flows necessary to protect fish and wildlife. However, the DNRC has consistently determined that objections to new water use permits have no legal standing unless the objector has a water right which would be adversely affected (See Addendum F-1). The DFWP has legal standing only on those streams where it has a water reservation or an instream right obtained pursuant to Section 89-801 RCM 1947 (Murphy's rights). DFWP has no such reservations or instream rights on the streams listed in this application.

To further illustrate this, the MDFWP has objected to the issuance of five new water permits, totalling 1,278 gallons per minute (GPM) and 458 acre-feet/year, for the Clark Fork River upstream from Milltown Dam (Table 1). These permits are concentrated in the Deer Lodge area on a section of river where summer dewatering is already severe. Objections were submitted on the grounds that additional summer water withdrawals from this river section would worsen an already borderline summer flow condition, further degrading the existing sport fishery. The DFWP requested, in its objections, that the possibility be investigated to restrict these and any new water permits to the high flow or spring runoff period when water in excess of existing demands is normally available in all years for new consumptive users.

Table 1. Water permit applications on the Clark Fork River upstream from Milltown Dam that were objected to by the DFWP since June, 1982.

Application No.	Diversion Rate (GPM)	Acre-Feet/Year
39866-S76G	200	96.70
42696	533	211.00
54583	210	75.36
59095	125	12.50
59176	210	62.00
	1,278	457.56

The DFWP withdrew its objection to one of the five permit applications. For the remaining four, its objections were ruled invalid by the DNRC because the DFWP lacked any instream rights or reservations for the Clark Fork River that would be adversely impacted by these new water permits. All permits were subsequently issued by the DNRC without having to address the concerns raised in the DFWP's objections.

In a letter dated September 6, 1985, (see Addendum F-2) the DFWP challenged the DNRC's decision to invalidate its objection to application No. 59176-S76G. Our argument was based on the grounds that the availability of water for additional consumptive users in the upper Clark Fork is in question and was made evident during the drought of 1985 when summer flows approached near zero levels. It is unclear if there are, in fact, unappropriated waters available for new users throughout the irrigation season in all years. The DFWP requested that a determination be made of what flow amounts are available, and at what time periods and frequencies, before any new permits are issued, and, further, that DFWP be provided with the water availability information used to support the issuance of these additional permits. Again, because of its lack of instream rights or reservations for the Clark Fork, the concerns expressed in the DFWP's letter were ruled invalid.

There are several large hydropower projects in the Clark Fork basin downstream from Milltown Dam. These include the Bureau of Reclamation's Hungry Horse Dam on the South Fork Flathead River, the Montana Power Company's Kerr Dam on Flathead Lake, and Washinton Water Power Company's Noxon Rapids and Cabinet Gorge dams on the lower Clark Fork River. Washington Water Power Company has a water right of 50,000 cfs at Noxon Rapids Dam, of which 15,000 cfs is by a provisional water use permit issued in 1976, and 35,000 cfs is by a right filed in 1951 (MDNRC 1986a). A flow of 50,000 cfs equals more than 36 million acre-feet per year--over twice the average annual discharge of the river at Cabinet Gorge Dam (16 million acre-feet). This right and the rights at the other hydro projects should, theoretically, preclude, or at least, limit the issuance of additional upstream consumptive water use permits. However, in addition to the 1976 permit issued to Washington Power Company, DNRC has issued, since 1973, 1,683 water use permits upstream of Noxon Rapids Dam--a total of 380,589 acre-feet of water. Of these, 214 permits, totaling 95,436 acre-feet, have been issued in the upper Clark Fork basin above Milltown Dam (MDNRC 1986b).

The downstream hydropower water rights have thus not affected the issuance of water use permits by DNRC, nor the use of water by the junior appropriators. In addition, DNRC is intervening in the relicensing and amending of operating licenses issued by the Federal Energy Regulatory Commission (FERC) with the intent of limiting the effect of the hydropower water rights on upstream consumptive use. In view of these circumstances, it is not practical or prudent to rely on the downstream hydropower water rights to protect instream flows in the Upper Clark Fork River.

The need for a reservation of water in the upper Clark Fork basin is brought about by the basic habitat requirements of the fish, wildlife and other living organisms that are dependent upon the flow of the Clark Fork River and its tributary streams. Due to the serious and chronic nature of the pollution in the upper Clark Fork, adequate streamflows must be maintained to prevent further deterioration in water quality and to help protect the investment being made to restore the river's water quality (See Johnson and Knudson 1985).

The requested water is needed to maintain fish habitat, aquatic insect populations and aquatic plant and animal life which sustain fish. Channel configuration in conjunction with flow provides the only living space available to aquatic organisms in streams. The existence of the stream fishery is dependent upon adequate streamflows for the maintenance of spawning and rearing areas, suitable shelter for fish, and production of food organisms that include aquatic macroinvertebrates and forage fish. In an aquatic ecosystem, water quantity is as critical a component of fish habitat as water quality.

Surface water in the upper Clark Fork River suffers from dramatic water pollution problems. The most serious problems are the result of decades of mining and smelting activities in the headwaters. There are massive deposits of mine tailings in the Butte area, along Silver Bow Creek, and at the sites of the Anaconda Smelter and Opportunity Pond system. Runoff entering Silver Bow Creek from these areas is acidic and has high concentrations of metals. Silver Bow Creek is treated with lime at the Warm Springs ponds to raise the pH and precipitate the metals which are in solution.

In addition to mine tailings in the Butte-Anaconda area, there are substantial deposits of mine tailings in the riparian zone and floodplain of the Clark Fork itself. These deposits are also chronic sources of metal contamination to the Clark Fork River.

There are several reasons for water pollution in the Clark Fork River which are related to flows: (1) High flows in the spring greatly increase metal concentrations by eroding mine tailings which have been deposited in the floodplain. Some of the highest metal concentrations in the Clark Fork occur during spring runoff (The DFWP's reservation for instream flow does not request flows of a magnitude that would cause increased levels of metals in the Clark Fork); (2) Flows in Silver Bow Creek which exceed the capacity of the Warm Springs ponds are bypassed directly into the upper Clark Fork; and, (3) Low flow conditions can aggravate water quality problems by reducing the amount of water available for dilution of industrial and municipal discharges, and non-point pollution. Current and future industrial and municipal waste discharge permits could be affected by chronic low flow conditions.

An instream flow reservation is needed to prevent the further deterioration of water quality during low flow periods. The reservation is also needed to provide adequate flows for enhanced aquatic populations which may occur in the future as existing pollution problems are reduced or, hopefully, eliminated.

The upper Clark Fork River and its tributaries are important fishing and recreation areas used by the people of Montana and the nation (Hagmann 1979). The recreational use of these waters is an important outlet from day-to-day pressures and is important in the human experience. Montana statutes recognize this resource as worthy of protection. The fish species which would be protected by this flow request contribute to the well-being of the people of Montana and visitors who enjoy the fishing opportunities Montana has to offer. In addition to sustaining existing recreation, adequate instream flows would preserve the opportunity to enhance fish populations which, in turn, would result in more recreational opportunities in the future.

It is contended that if the requested reservations are not provided, the deterioration of previously described aquatic and recreational interests is inevitable. The rate of deterioration would depend on the degree to which further dewatering would be allowed to occur.

This request is for the amount of water necessary to sustain the organisms without significant long-term reduction in quantity and quality. Increased water withdrawals over existing levels would, in the long run, reduce availability of habitat and consequently reduce the number of organisms which can occupy that habitat. There is a limit to the amount of water which can be removed from any stream channel without severely changing the quantity and quality of the aquatic species present, or limiting the biological potential of the stream. In portions of the upper Clark Fork River basin, that limit has already been exceeded.

All aquatic animals depend for their existence on lower forms of plants or other animals. These lower forms also have specific water requirements necessary to sustain growth and reproduction. Reduction in availability of lower aquatic forms ultimately reduces the number, health and well-being of those organisms at higher trophic levels.

Reduced streamflows during the normal low flow period also affect the quality of water which is necessary to sustain aquatic organisms. Possible consequences of this lowered streamflow are higher water temperatures, increased amounts of dissolved solids, increased nutrient concentrations and lower dissolved oxygen levels. Reduced streamflows seasonally limit the ability of the Clark Fork to assimilate its present pollution load. Reduced tributary streamflows reduce the important capability of tributary streams to discharge clean water into the Clark Fork for dilution of pollutants.

Thus, there are several ways reduced streamflow can adversely affect aquatic organisms: (1) decreasing the physical size and character of living space; (2) altering the food chain by reducing availability of food organisms; and, (3) changing water quality which alters living conditions for plant and animal life. Therefore, streamflows must be protected from further depletion to prevent loss of those habitat conditions which allow aquatic organisms to survive.

The riparian ecosystem of the Clark Fork River and its tributaries is a transitional zone, or ecotone, between the aquatic and terrestrial habitats. This streamside zone of vegetation is characterized by the combination of high species diversity, high species densities, and high productivity. Many of the trees and shrubs that dominate this zone require groundwater within their rooting zones throughout the growing season.

The riparian zone is ecologically important because it provides seasonal and yearlong habitat for greater numbers and species of wildlife than any other habitat in Montana. In addition to its rich assemblage of plants and animals, the riparian zone plays an essential role in determining the quality of the aquatic environment for supporting fish and aquatic invertebrates. It also provides a buffer zone for dissipating overland flood flows and it has high aesthetic and recreational values.

The extent and quality of riparian zones are directly linked to shallow groundwater tables that are continuous with, and recharged by, surface streamflows. Fluctuations in streamflow cause concomittant fluctuations in associated shallow groundwater tables. Although the specific relationships among riparian vegetation and the amount and availability of groundwater have not been quantified in the upper Clark Fork drainage, requested instream flows are essential to the perpetuation of the existing plant communities and associated wildlife populations.

STATEMENT OF THE AMOUNT OF WATER NECESSARY FOR THE PURPOSE OF THE RESERVATION

C. STATEMENT OF THE AMOUNT OF WATER NECESSARY FOR THE PURPOSE OF THE RESERVATION

1. Introduction:

There are two kinds of flow requests presented in this application:

(1) Those flows necessary to maintain physical fish habitat quality in all streams on a year-round basis.

Physical habitat in a stream is essential if a fishery is to be maintained. The first type of flow recommendation is based on the physical stream habitat requirements as determined by the Wetted Perimeter Inflection Point method. The flows recommended in most cases are those necessary to maintain a high level of aquatic habitat potential in each stream. Flows are requested for all months of the year for each stream reach and are presented in the section entitled "Instream Flow Requests--Habitat Quality".

(2) Those tributary flows necessary to maintain existing water quality in the Clark Fork River from January through April.

Good water quality is also essential for maintaining a stream fishery. The second type of flow recommendation is based on the need to maintain adequate dilution in the Clark Fork River for toxic metals which originate in the Warm Springs settling ponds. Toxicity is particularly high from January through April. The rationale for this request is outlined in the section entitled "Water Quality Considerations".

A summary of both types of flow requests is presented in Table 11.

As long as the status quo in water quality exists in the headwaters of the Clark Fork, there will be a need to have sufficient tributary flows entering the Clark Fork to dilute pollutants. Sufficient flows are now occuring from tributary streams during the winter months because there is little diversionary use of these waters during this period, and all, or nearly all, available flow is entering the Clark Fork.

As reclamation plans proceed and are, hopefully, successfully implemented, the toxicity of the water entering the Clark Fork from the settling ponds and other headwater areas should be reduced. As this occurs, there will be less demand for the entire flow from tributary streams from January-April. However, until reclamation is completed, all of the instantaneous base flow of tributary streams is requested in this application from January 1 - April 30.

These flow requests are in addition to the year-round flows requested for physical habitat maintenance. The entire flow is requested because any reduction in flow over that which presently exists will reduce the water quality. If and when reclamation occurs, the Board of Natural Resources has the option to review the requested flows and alter them if necessary.

2. Instream Flow Method

Numerous techniques have been developed for determining the instream flow requirements of fish and other aquatic life forms. These range from relatively simple office methods which base their recommendations on some flow quantity derived from the historic flow record (such as a percentage of the mean annual flow), to the derivation of the actual biological-flow relationships from long-term field data collected in drought, normal and above normal water years.

The former approach was not used because the DFWP believes that instream flow recommendations should, wherever possible, reflect stream-specific habitat and discharge relationships rather than a flow quantity derived solely from the flow record. Furthermore, the lack of sufficient flow data for the vast majority of Montana's streams precluded the use of virtually all office methods. More over, the consensus among professionals is that this approach should be confined to deriving only preliminary or reconnaissance-grade recommendations (Estes and Orsborn 1986; Stalnaker and Arnette 1976).

Use of biological-flow relationships was impractical due to the extensive commitment of time, money and manpower that are needed to collect the ten or more years of field data that could be required to define these relationships for a particular stream or stream reach. Even if such long-term data were available for the Clark Fork River, their usefulness for instream flow determinations on this stream would be minimized due to the overwhelming influence of chronic mine pollution on the fishery.

The DFWP, recognizing the shortfalls of these approaches for this application, adopted the Wetted Perimeter Inflection Point Method to determine fishery flow needs based on stream channel and flow characteristics. This method focuses on the assumption that the food supply can be a major factor influencing a stream's carrying capacity (the total number and pounds of fish that can be maintained by the aquatic habitat). The principal food of many of the juvenile and adult game fish inhabiting the streams of Montana is aquatic invertebrates, which are produced primarily in stream riffle areas. The method assumes that the game fish carrying capacity is proportional to the amount of wetted perimeter in riffles.

Wetted perimeter is the distance along the bottom and sides of a channel cross-section in contact with water (Figure 3). As the flow in a stream channel increases, the wetted perimeter also

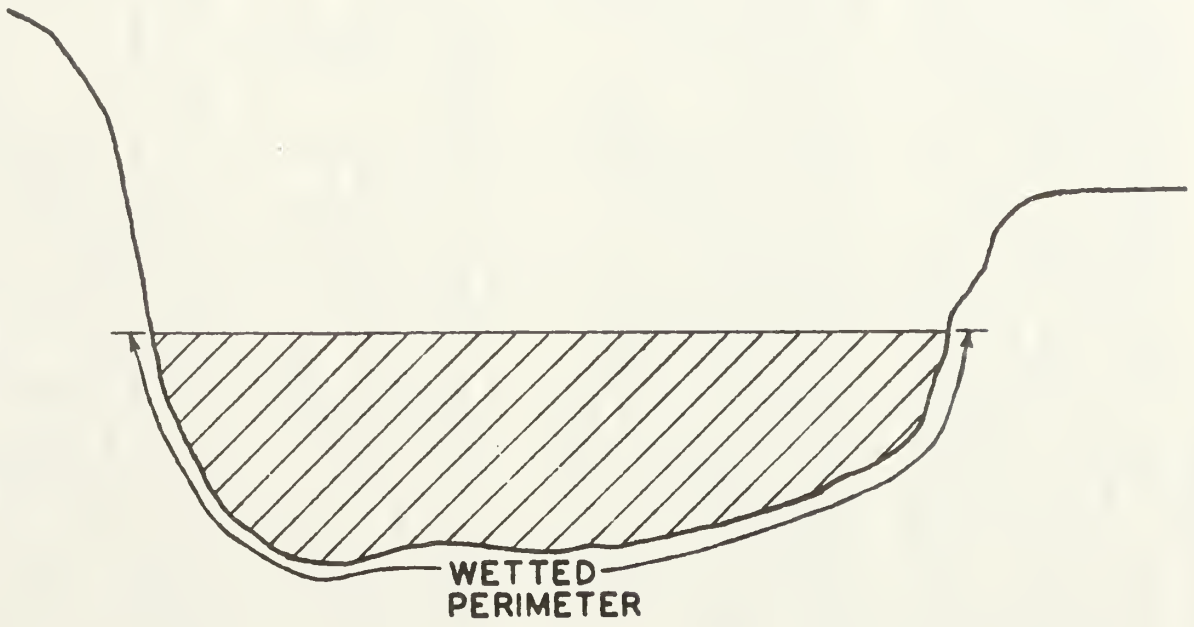


Figure 3. The wetted perimeter in a channel cross-section.

increases, but the rate of gain of wetted perimeter is not constant throughout the entire range of flows.

A plot of wetted perimeter versus flow for stream riffle cross-sections generally shows two points, referred to as inflection points, where the rate of gain of wetted perimeter abruptly changes. In the example (Figure 4), these inflection points occur at approximately 8 and 12 cfs. Below the lower inflection point, the stream flow is spreading out horizontally across the bottom, causing the wetted perimeter to increase rapidly for very small increases in flow. A point is eventually reached (at the lower inflection point) where the water starts to move up the sides of the active channel and the rate of increase of wetted perimeter begins to decline. At the upper inflection point, the stream is approaching its maximum width and begins to move up the banks as flow increases. Large increases in flow beyond the upper inflection point cause only very small changes in wetted perimeter.

The area available for food production is considered near optimal at the upper inflection point because almost all of the available riffle area is wetted. At flows below the upper inflection point, the stream begins to pull away from the riffle bottom until, at the lower inflection point, the rate of loss of wetted bottom begins to rapidly accelerate. Once flows are reduced below the lower inflection point, the riffle bottom is being exposed at an accelerated rate and the area available for food production greatly diminishes. The method is intended to describe a threshold below which a stream's food producing capacity begins to decline (upper inflection point) and a threshold at which the loss becomes unacceptable (lower inflection point).

While this inflection point concept focuses on food production, there are indications that wetted perimeter relates to other factors that influence a stream's carrying capacity. One such factor is cover (or shelter), a well recognized component of fish habitat.

In the headwater streams of Montana, overhanging or submerged bank vegetation and undercut banks are important components of cover. The wetted perimeter-flow relationship for a stream channel is, in some cases, similar to the relationship between bank cover and flow. At the upper inflection point, the water begins to pull away from the banks, decreasing the amount of bank cover associated with water. Flows exceeding the upper inflection point are considered to provide near optimal bank cover. At flows below the lower inflection point, the water is sufficiently removed from the bank cover to severely reduce its value as fish shelter. Support for this relationship is provided by Randolph (1984), who found a high correlation between riffle wetted perimeter at various flows and the total area of overhanging bank vegetation (r=0.88-1.00) and undercut banks (r=0.84-0.97) for three study sections in a small Montana stream.

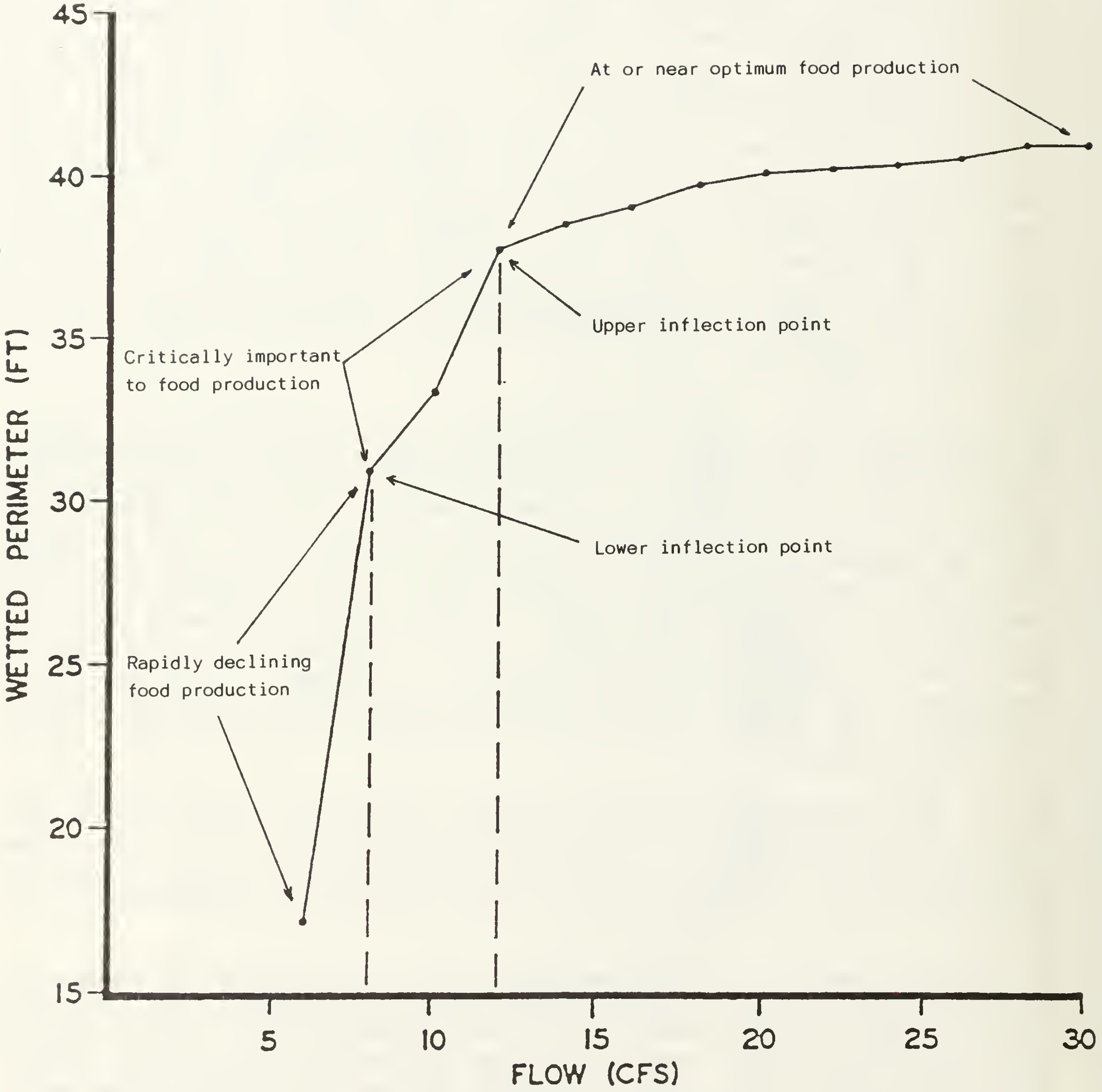


Figure 4. An example of a relationship between wetted perimeter and flow for a stream riffle cross-section showing upper and lower inflection points and their relationship to fish food production.

In addition to producing food, riffles also are used by many game fish species for spawning and the rearing of their young (Sando 1981 and Loar et al. 1985). Consequently, the protection of riffles ensures that the habitat required for these critical life functions is also protected.

Riffles are the area of a stream most affected by flow reductions (Bovee 1974, Nelson 1977 and Loar, et al. 1985). By providing a recommendation that wets a large portion of the available riffle area, we are, at the same time, also protecting both runs and pools--areas where adult fish normally reside.

The Wetted Perimeter Inflection Point Method provides a range of flows (between and including the lower and upper inflection points) from which a single instream flow recommendation is selected. Flows below the lower inflection point are judged undesirable based on their probable impacts on food production, bank cover, and spawning and rearing habitats, while flows at and above the upper inflection point are considered to provide near optimal conditions for fish. The upper and lower inflection points are believed to bracket those flows needed to maintain high and low levels of aquatic habitat potential. These habitat levels are defined as follows:

(1) High level of Aquatic Habitat Potential - That flow regime which will consistently produce abundant, healthy and thriving aquatic populations. In the case of game fish species, these flows would produce abundant game fish populations capable of sustaining a good to excellent sport fishery for the size of stream involved. For rare, threatened or endangered species, flows to accomplish the high level of aquatic habitat maintenance would: (a) provide the high population levels needed to ensure the continued existence of that species, or (b) provide the flow levels above those which would adversely affect the species.

(2) Low Level of Aquatic Habitat Potential - That flow regime which will provide for only a low population of the species present. In the case of game fish species, a poor sport fishery could still be provided. For rare, threatened or endangered species, their populations would exist at low or marginal levels. In some cases, this flow level would not be sufficient to maintain certain species.

The final flow recommendation is generally selected from this range of flows by a concensus of the biologists who collected, summarized and analyzed all relevant field data for the stream of interest. The biologists' analyses of the stream resource form the basis of the flow selection process. Factors considered in the evaluation include: (1) level of recreational use, (2) existing level of environmental degradation, (3) water availability, and (4) size and composition of existing fish populations. Fish population information is a major consideration for all streams. A marginal or poor fishery may only justify a flow recommendation at or near the lower inflection point unless other considerations, such as the presence of species of "special concern" (arctic grayling and cutthroat trout, for example) warrant a higher flow. In general, streams with exceptional resident fish populations, those providing crucial spawning and/or rearing habitats for migratory populations, and those supporting significant populations of species of "special concern" should be considered for flow recommendations that are at or near the upper inflection point. The Clark Fork tributaries for which flows are being requested in this application are those with the highest resident fishery and/or spawning values and, consequently, upper inflection point flows are requested for most of these streams. There are a few streams where flows less than the upper inflection point are recommended for reasons stated later.

Other streams considered for upper inflection point recommendations are streams that have the capacity to provide an outstanding fishery, but are prevented from reaching their potential because of stream dewatering. Flows at the upper inflection point provide a goal to strive for should the means become available to improve streamflows through such means as water storage projects or the purchase of irrigation rights. Streams that are subjected to other forms of environmental degradation, such as mining pollution, and which have the potential to support significant fisheries if reclaimed, are additional candidates for upper inflection point recommendations. Both of these categories describe the Clark Fork River and most of its tributaries, thus qualifying them for upper inflection point recommendations.

The wetted perimeter-flow relationships for the Clark Fork River and its tributaries were derived using a wetted perimeter predictive (WETP) computer program developed in 1980 for the DFWP. WETP is a relatively simple computer model that eliminates the more complex data collecting and calibration procedures associated with other similar computer programs in current use, while at the same time providing more accurate and reliable wetted perimeter predictions. An in-depth description of the WETP computer program and data collection procedures is provided in a publication titled "Guidelines for Using the Wetted Perimeter (WETP) Computer Program of the Montana Department of Fish, Wildlife and Parks" (Nelson 1984).

When deriving instream flow recommendations for the rivers and streams of Montana, the DFWP normally divides the annual flow cycle into two separate periods: (1) a relatively brief snow runoff or high flow period, when a large percentage (about 75%) of the annual water yield is passed through the system, and (2) a non-runoff or low flow period which is characterized by relatively stable base flows maintained primarily by groundwater outflow. For headwater rivers and streams, the high flow period generally includes the months of May, June and July while the remaining months (approximately August through April) encompass the low flow period.

The wetted perimeter inflection point method is normally applied only to the low flow period, and a separate method that addresses the high flow functions of channel maintenance and flushing of bottom sediments is applied to the high flow period. However, due to the deposition of toxic mine wastes in the Clark Fork's stream banks and surrounding flood plain, an instream reservation for a portion of the high flows is not being requested. High flows cause these wastes to be washed into the river where they become hazardous to fish and other aquatic organisms. Consequently, the flow recommendations derived from the Wetted Perimeter Inflection Point Method are requested year-round for the Clark Fork River and its tributaries.

In summary, the method used to determine the requested instream flows for all streams and stream reaches in this application is the same -- the Wetted Perimeter Inflection Point Method combined with a knowledge of the fishery gained through field observations and electro-fishing surveys. Exceptions are Cable and Stuart Mill Creeks where stable flows prevented the collection of the field data needed to calibrate the WETP computer program.

Addendum C to this application is a comprehensive survey of the instream flow methods literature, and relates the significance of existing methods to Montana's Wetted Perimeter Inflection Point Method (Leathe and Nelson 1986). This synopsis includes the history of instream flow development, the relationship between streamflows and fish populations, a survey and analysis of instream flow methods (including available techniques, advantages and limitations, evaluation studies, and criteria for selecting an instream flow method), and finally, a discussion of why Montana chose to use the wetted perimeter inflection point method in its instream flow program. This synopsis is an important component of the DFWP's method and justification for the flows requested in this application.

3. Clark Fork River Basin Description

The Clark Fork of the Columbia River originates in the Silver Bow (or Highland) Mountains south of Butte, Montana, and flows northwestward approximately 350 river miles to Lake Pend Oreille in northern Idaho (see Figure 1). The portion of the Clark Fork basin in Montana encompasses an area of 22,000 square miles. The basin is mountainous and covered with large forested tracts, the continuity of which is broken by grazing and cropland areas situated in valleys at lower elevations.

Over 150 tributaries drain into the Clark Fork in Montana. The largest are the Flathead, Bitterroot and Blackfoot rivers which enter the Clark Fork River 106, 212 and 226 river miles upstream from Pend Oreille Lake, respectively. These three rivers account for over half of the drainage area in the Clark Fork River basin (Table 2).

Table 2. Principal U.S. Geological Survey gaging stations, drainage areas, and stream discharges for their periods of record--Clark Fork River basin[1]

Station	Years of Record	Drainage Area (mi²)	Discharge (cfs) Mean	Max.	Min.
Clark Fork River at Deerlodge	7	1,005	343	2,500	25
Clark Fork River at Drummond	11	2,378	889	15,800	58
Blackfoot River near Bonner	49	2,290	1,636	19,200	200
Clark Fork River above Missoula	56	5,999	3,037	32,300	115
Bitterroot River near Florence	8	2,354	2,336	20,300	365
Clark Fork River below Missoula	56	9,003	5,523	52,800	388
Clark Fork River at St. Regis	75	10,709	7,555	68,900	870
Flathead River near Polson	78	7,096	11,680	82,800	32
Clark Fork River near Plains	75	19,958	19,950	134,000	3,200
Clark Fork River at Whitehorse Rapids below Cabinet, Idaho	57	22,073	22,370	153,000	762[2]

[1] Data presented is through water year 1985. The "Clark Fork River at Drummond" station has been discontinued. All the other stations were operative in 1985.

[2] Minimum daily since Cabinet Gorge Reservoir was filled. Minimum discharge during filling of reservoir was 270 cfs.

The five largest cities in the drainage are Butte, Missoula, Anaconda, Kalispell and Deer Lodge. The Clark Fork basin has been widely known for its mining and smelting industries. The copper mines at Butte and smelters at Anaconda (which recently closed) are internationally famous. Logging, lumbering and paper manufacturing are industries supported by forests of the basin.

The tourist trade is a large contributor to the economy, and agriculture is an important industry in the basin. The basin is nationally known for its scenic beauty, fishing, hunting and other recreational features.

The Clark Fork River system is one of the major tributaries of the Columbia River, as it contributes over 10 percent of the annual runoff of the Columbia River at The Dalles, Oregon. Average annual streamflow of the Clark Fork near the Montana-Idaho line is 22,370 cfs. The drainage area is 22,073 square miles.

Because of differences in biological and streamflow characteristics the Clark Fork River is divided into three reaches: (1) The upper Clark Fork - from its headwaters to its confluence with the Blackfoot River (125 river miles); (2) The middle Clark Fork - from the mouth of the Blackfoot to the mouth of the Flathead River (120 miles); and, (3) The lower Clark Fork - from the Flathead to Pend Oreille Lake (106 miles).

This reservation application includes only the upper Clark Fork River and selected tributaries, which are described in greater detail in the following section.

4. Upper Clark Fork River Basin Description

This application for reservation of instream flow encompasses the Clark Fork River from the confluence of Silver Bow and Warm Springs Creeks downstream to the mouth of the Blackfoot River as well as selected tributaries, including Warm Springs Creek, Racetrack Creek, Dempsey Creek, Lost Creek, Gold Creek, Flint Creek, Harvey Creek, Little Blackfoot River and two of its tributaries (Dog and Snowshoe creeks) (Figure 5).

The reservation application does not include the Rock Creek drainage or the Blackfoot River drainage. Both Rock Creek and the Blackfoot River have instream flow rights with January 1971 priority dates. These instream flow rights were filed under provisions of Chapter 345, Laws of 1969 and later codified as Section 89-801, R.C.M. 1947. This act allowed the Montana Fish and Game Commission to file for the unappropriated waters of selected streams of the state in amounts necessary for the preservation of fish and wildlife habitat. No other waters in the upper Clark Fork River basin have similar streamflow protection.

The Clark Fork River begins at the confluence of Warm Springs and Silver Bow Creeks. Its headwaters drain the west flank of the Continental Divide and the Anaconda Range. The upper Clark Fork is bordered on the north by the Garnet Range and on the south by the Flint Creek Range and the John Long and Sapphire mountains. The average stream gradient between Warm Springs Creek and Milltown Dam is about 13 feet per mile.

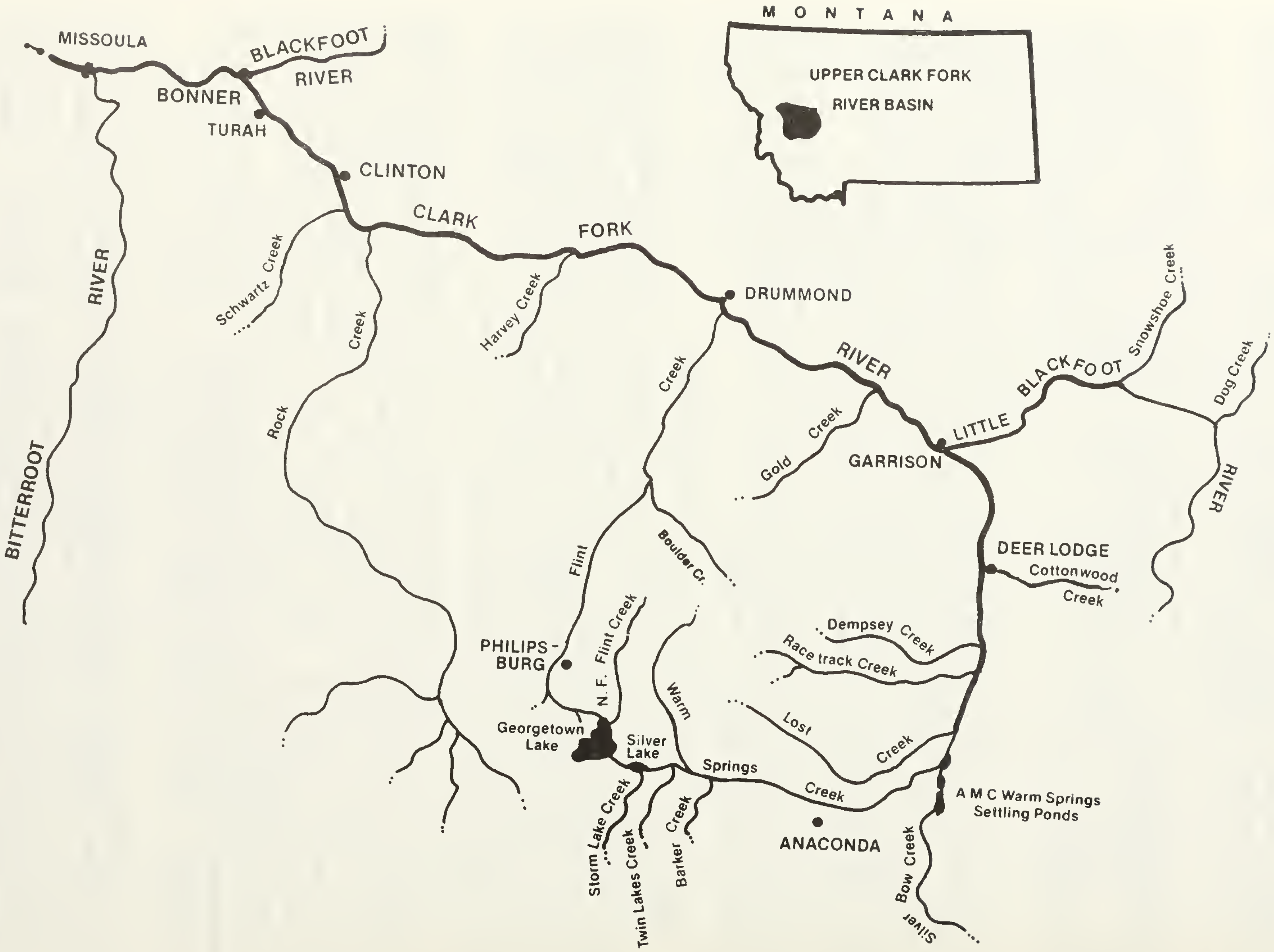


Figure 5. Upper Clark Fork of the Columbia River Basin.

The largest cities in the upper drainage are Butte, Anaconda, and Deer Lodge. The smaller communities include Bonner, Clinton, Drummond, Philipsburg, Garrison and Avon. State, national, and private forests in the upper basin support logging, lumbering, and paper manufacturing in, or very near, the area. Recreation and agriculture are also very important to the economy of the upper basin.

Much of the area is highly mineralized. Perhaps the greatest influence in the upper Clark Fork basin during the last 100 years has been the activity of the mining and smelting industries. The mines at Butte and the smelters at Butte and Anaconda were internationally famous. Butte had the reputation of being the world center for mining technology. The Butte hill has been variously referred to as "the richest hill on earth" and "the greatest mineral deposit this world had ever seen." The extraction, concentration, and ultimate smelting of that mineral deposit has been the dominant economic, social, political and environmental influence in the upper Clark Fork basin during the last 100 years. The wastes generated, and for years discharged directly into the river, have virtually become a part of the riparian ecology of the upper Clark Fork. The legacy of that era is the poor environmental conditions found in the upper Clark Fork basin today.

Two hydropower projects are located in the upper Clark Fork drainage. Flint Creek Dam and powerhouse is located at the outlet of Georgetown Lake, 38 miles upstream from the mouth of Flint Creek. Milltown Dam is located on the main stem of the Clark Fork at the town of Bonner. Milltown Dam marks the lower boundary of the present instream flow reservation request.

Major tributaries to the upper Clark Fork include the Little Blackfoot River, Flint Creek, Rock Creek, and Blackfoot River. Flow reservations are not requested for the Blackfoot River or Rock Creek, although these flows are utilized in certain flow calculations for the Clark Fork River. Mean annual discharge for the period 1951 to 1982 for the Clark Fork at Deer Lodge is 365 cfs. The mean discharge at Drummond for the same period increases to 889 cfs. A complete analysis of these flow records can be found in Addendum A.

The upper Clark Fork River has been divided into four sections to correspond to changing streamflow characteristics related to the inflow of the major tributaries. Section 1 begins at the confluence of Warm Springs Creek and Silver Bow Creek and extends downstream to the mouth of the Little Blackfoot River. Flow in this reach can be correlated to the USGS gage "Clark Fork River at Deer Lodge." Section 2 extends from the mouth of the Little Blackfoot River downstream to the mouth of Flint Creek. Flows in this reach are monitored by the USGS gage "Clark Fork River near Gold Creek." Section 3 extends from the mouth of Flint Creek downstream to the mouth of Rock Creek, and flows for this reach are monitored by the USGS gage "Clark Fork River near Clinton", upstream from the mouth of Rock Creek. Section 4 extends from the mouth of Rock Creek to Milltown Dam. Flows in this reach were determined by using the USGS gage "Clark Fork River above Missoula" corrected for inflow from the Blackfoot River ("Blackfoot River near Bonner").

A brief description of the fishery of the upper Clark Fork River from Warm Springs Creek to Milltown Reservoir is presented here to facilitate an overall understanding of this important resource. The data given are based on fish population estimates obtained by electrofishing in several sections of the river. The reader is also referred to Workman (1985) for a short, but concise history of the Clark Fork fish populations.

Four reaches of the Clark Fork are discussed: Reach #1 - from Warm Springs Creek to the mouth of the Little Blackfoot River; Reach #2 - from the Little Blackfoot River to the mouth of Flint Creek; Reach #3 - from Flint Creek to the mouth of Rock Creek; and Reach #4 - from Rock Creek to Milltown Reservoir.

Reach #1. The best fish population in the upper Clark Fork occurs in a two-mile stretch of river below Warm Springs Creek. Over 2,300 brown trout per mile have been estimated here. The population becomes smaller below this stretch; in the Sager Lane section above Deerlodge, the population averages less than 400 brown trout per mile. Below Deerlodge, in the Williams-Tavenner section, the brown trout population has averaged less than 250 fish per mile. Throughout Reach #1, brown trout comprise over 95 percent of the trout population, with other trout species making up less than five percent.

Reach #2. A section below the Little Blackfoot River (at Phosphate) has revealed an average of 295 trout per mile of all trout species combined. The trout species composition of this reach is over 95 percent brown trout, with less than five percent other trout species.

Reach #3. The smallest trout population in the upper Clark Fork occurs in this reach. Data from two electrofishing sections (Bearmouth and Bonita) revealed an average of less than 70 trout per mile of all species combined. However, the population is now comprised of approximately 66 percent brown, 19 percent rainbow, and 15 percent cutthroat trout.

Reach #4. Rock Creek enters this reach, contributing cool, clean water to the Clark Fork. An electrofishing section at Turah (between Rock Creek and Milltown Reservoir) shows trout populations improved over Reach #3. An average of 378 trout per mile of all species has been found in this reach. Also, the population is now comprised of approximately 53 percent brown and 45 percent rainbow trout, with about two percent other trout species.

Physical and biological characteristics, as well as instream flow methods and recommendations for these reaches are described in the next section.

The Montana Natural Heritage Program[1] lists 60 vertebrate species which are ranked rare, imperiled or critically imperiled in Montana. Six (10%) of these species occur in the upper Clark Fork basin (in Missoula, Granite, Deerlodge and Powell counties) and either live in streams or are associated with the riverine riparian areas.

Two of the species are ranked globally rare, imperiled or critically imperiled, and are listed as endangered in Montana by the U.S. Fish and Wildlife Service.

The species referred to above and their rankings are listed below.

Common Name	Scientific Name	Rank	Federal Status in Montana
Tailed frog	Ascaphus Truei	S3/G5	-
Common loon	Gavia Immer	S3/G5	-
Peregrine falcon	Falco Peregrinus	S1/G3	Endangered
Bald eagle	Haliaeetus Leucocephalus	S2/G3	Endangered
Westslope cutthroat trout	Salmo Clarkii Lewisi	S3/G5	-
Shorthead sculpin	Cottus Confusus	S3/G5	-

These ranks represent the priority assigned by the Natural Heritage Program for data collection and protection both nationally and within the state. Both rankings are determined on a numeric scale: 1 (critically imperiled) to 5 (demonstrably secure). A detailed definition of these ranks follows.

State Rank	Definition
S1	Critically imperiled in Montana because of extreme rarity (5 or fewer occurrences or very few remaining individuals), or because of some factor of its biology making it especially vulnerable to extirpation from the state. (Critically endangered in state).

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[1] Montana State Library, 1515 E. 6th Ave., Helena, MT 59620.

S2	Imperiled in Montana because of rarity (6 to 20 occurrences), or because of other factors demonstrably making it very vulnerable to extirpation from the state. (Endangered in state).
S3	Rare in Montana (on the order of 20+ occurrences). (Threatened in state).
S4	Apparently secure in Montana.
S5	Demonstrably secure in Montana.

Global Rank	Definition
G1	Critically imperiled globally because of extreme rarity (5 or fewer occurrences or very few remaining individuals), or because of some factor of its biology making it especially vulnerable to extinction. (Critically endangered throughout range).
G2	Imperiled globally because of rarity (6 to 20 occurrences) or because of other factors demonstrably making it very vulnerable to extinction throughout its range. (Endangered throughout range).
G3	Either very rare and local throughout its range or found locally (even abundant at some of its locations) in a restricted range, or because of other factors making it vulnerable to extinction throughout its range; in the range of 21 to 100 occurrences. (Threatened throughout range).
G4	Apparently secure globally, though it may be quite rare in parts of its range, especially at the periphery.
G5	Demonstrably secure globally, though it may be quite rare in parts of its range, especially at the periphery.

In the upper Clark Fork basin, potential nesting habitat has been documented for the bald eagle in Rock Creek, where a pair of eagles was observed between Ranch Creek and the mouth of Rock Creek. Potential bald eagle nesting habitat has been documented on the Clark Fork River in the Gold Creek vicinity. A pair of eagles nested in the area in 1986 but failed to produce offspring. Probability of re-nesting in 1987 is high. The upper Clark Fork is also used by bald eagles during the winter. The area is not considered key winter habitat, but some birds use the area randomly while migrating from northern summer areas to southern winter habitat. Also, a few birds remain all winter along the Clark Fork from Garrison to Milltown Dam (and beyond). The bald eagle is currently classified as an endangered species in Montana pursuant to the Endangered Species Act (DFWP 1986c).

The Peregrine falcon, another endangered species in Montana, occurs as a casual migrant in the upper Clark Fork. Peregrines have been re-introduced into Beaverhead, Madison and Gallatin counties in recent years. They have been observed on occasion in the fall and spring and are probably using the Clark Fork as a migration route between summer and winter habitats (DFWP 1986c).

The shorthead sculpin has been found in the Little Blackfoot River, and the westslope cutthroat trout has been found in Barker Creek, Twin Lakes Creek, Little Blackfoot River (Reach #1), Dog Creek and Flint Creek (Reach #2). It is probable they could occur in some other streams in the upper Clark Fork basin.

The tailed frog inhabits the upper reaches of headwater streams. It's preferred habitat is the colder, rushing water of the higher gradient stream reaches (Natural Heritage Program).

The common loon occurs infrequently or during migration periods in the upper Clark Fork. No breeding occurs. This species prefers longer, flat water reaches of stream (Natural Heritage Program).

5. Instream Flow Requests--Habitat Quality

STREAM NAME: Clark Fork River

STREAM REACH: #1. From the mouth of Warm Springs Creek to the mouth of the Little Blackfoot River - 37.8 miles.

LOCATION: Sec. 18, T5N, R9W to Sec. 23, T9N, R10W

DESCRIPTION OF STREAM REACH:

Most of this reach lies within the broad and flat plains of the Deer Lodge valley. Major tributaries entering within Reach #1 are Dempsey, Racetrack, Lost, Modesty and Cottonwood creeks.

River channel widths at or near recommended flows are 50 feet near Warm Springs and 75 feet near the Williams-Tavenner bridge below Deer Lodge. Throughout most of the Deer Lodge valley, the Clark Fork River slowly meanders through poorly sorted silt, sand, and gravel alluvium (McMurtrey et.al. 1964). Ganser (1983) reports that the average stream gradient for this reach is 8.1 feet/mile, although this value increases to around 15.0 feet/mile at the lower end of the reach just above the Little Blackfoot River.

Physical stream habitat conditions vary widely throughout the reach. Overhanging vegetation and bank stability are good in the upper end of the reach, but these conditions become progressively worse in a downstream direction. Major transportation corridors have had little impact upon the river's streambanks or channel. Cattle grazing and mine spoils have caused some loss of riparian vegetation. Collapsed streambanks, visible indicators of overused riparian areas, are evident.

Major water quality impacts include metals, non-point runoff from agricultural lands, and domestic wastewater from the communities of Butte, Anaconda, Warm Springs, Deer Lodge, Opportunity and Galen. The impact from metals is significant. Suspended and dissolved metals originating from the Anaconda Mining Company's (AMC) Butte and Anaconda operations severely impacted this reach for nearly 100 years. Even today, mine tailings that have been deposited along much of the floodplain are resuspended during runoff events. A large fish kill in the river above Deer Lodge during August 1984, demonstrated the severity of this problem. Several thousand trout were killed when a thunderstorm washed tailings into the river (Pedersen and Phillips 1984).

The riparian vegetation of the Clark Fork, between Warm Springs and Garrison, has been altered from its natural condition by agricultural and mining activities. Irrigated and sub-irrigated hay meadows commonly occur on the floodplain terraces adjacent to the river where the natural vegetation has been removed. These managed meadows are dominated primarily by smooth brome (Bromus *inermis*), meadow foxtail (*Alopecurus pratensis*), redtop (*Agrostis alba*) and Kentucky bluegrass (*Poa pratensis*).

Mining spoils have been deposited on riverbanks and oxbows and have killed or severely stressed the vegetation due to metal toxicity. The native plant communities that occur interspersed among the spoils deposits are dominated by willows (*Salix* spp.), river birch (*Betula occidentalis*) and an occasional cottonwood (*Populus trichocarpa*). Understory species include sedges (*Carex* spp.), introduced hay-meadow grass species, tufted hairgrass (*Deschampsia cespitosa*) and various forb species.

A typical riparian forest, composed of several strata of shrub and tree canopies, is not well developed on this reach of the river. Plant species diversity also appears to be low as a result of metals impacts from waterborne spoils. Species resistant or adapted to metal toxicity tend to predominate.

GAME FISH SPECIES PRESENT: Brown trout, rainbow trout, cutthroat trout, brook trout, bull trout, mountain whitefish.

FISHERY:

Although other trout species inhabit this reach of stream, they are far outnumbered by brown trout. Brown trout comprise over 95 percent of the total trout population. Brown trout populations are larger in the first two miles of stream below Warm Springs Creek than anywhere else in the upper Clark Fork River. Sculpins, normally an important trout food source, are common in the reach.

Three sections where fish population estimates have been made are within this reach. Two of the sections (near the pH shack just below the confluence of Warm Springs Creek and near the Williams-Tavenner bridge below Deer Lodge), have been sampled since 1967. The other section (near Sager Lane, approximately 12 miles below the pH shack section) was sampled in 1981 and 1982. The results of these population estimates are presented in Table 3.

The numbers of trout in the pH shack section are very high compared to the Sager Lane and Williams-Tavenner sections. Since implementation of better waste treatment practices at the AMC Butte operations, and better "liming" procedures at the Warm Springs ponds, the combination of which occurred around 1972, trout populations have substantially increased in the pH shack section. No trout were found in this section in 1972, while an estimate in spring 1979 found over 1,500 trout per mile. The dramatic recovery of the pH shack section's trout fishery has not been extended to the Sager Lane or Williams-Tavenner sections, where the average population is less than 400 trout/mile.

WILDLIFE:

Wildlife species utilizing the riparian areas of Reach #1 include whitetail deer, mule deer, beaver, mink, muskrat and several species of waterfowl. Several ponds within this reach are managed for waterfowl production. Bald eagles utilize the river corridor during the winter.

Table 3. Estimated numbers of brown trout per mile in the pH Shack, Sager Lane and Williams-Tavenner, sections, 1972-1986.

Year	Section		
	pH Shack Spring	Sager Lane Spring	Williams-Tavenner Spring
1972	0		106
1974	361		
1977	347		272
1978	890		165
1979	1509		355
1980	1400		256
1981	1054	418	245
1982	892	373	217
1983	---		---
1984	1930		224
1985	1937		103
1986	2334		143

WETTED PERIMETER:

Cross-sectional measurements were made in an approximate 910-foot section of Reach #1 (NE Sec. 9, T8N, R9W), approximately 5.0 miles downstream from the community of Deer Lodge. Five cross-sections were established. The WETP program was calibrated to field data collected at flows of 69.7 and 318.3 cfs.

The relationship between wetted perimeter and flow from a composite of the five riffle/run cross-sections is shown in Figure 6. Lower and upper inflection points occur at approximate flows of 90 and 180 cfs, respectively.

WHY FLOW IS NECESSARY:

The requested flow is necessary to maintain the physical habitat for existing resident and migratory trout populations, and to make flows available for those species which are currently absent or exist in reduced numbers, but which could become better established if water quality is improved through mining waste reclamation; and to contribute to the maintenance of habitat conditions for those wildlife species which depend upon the stream and its riparian zone for food, water, and shelter.

FLOW REQUEST:

January 1 - December 31--180 cfs (130,314 A.F./yr)

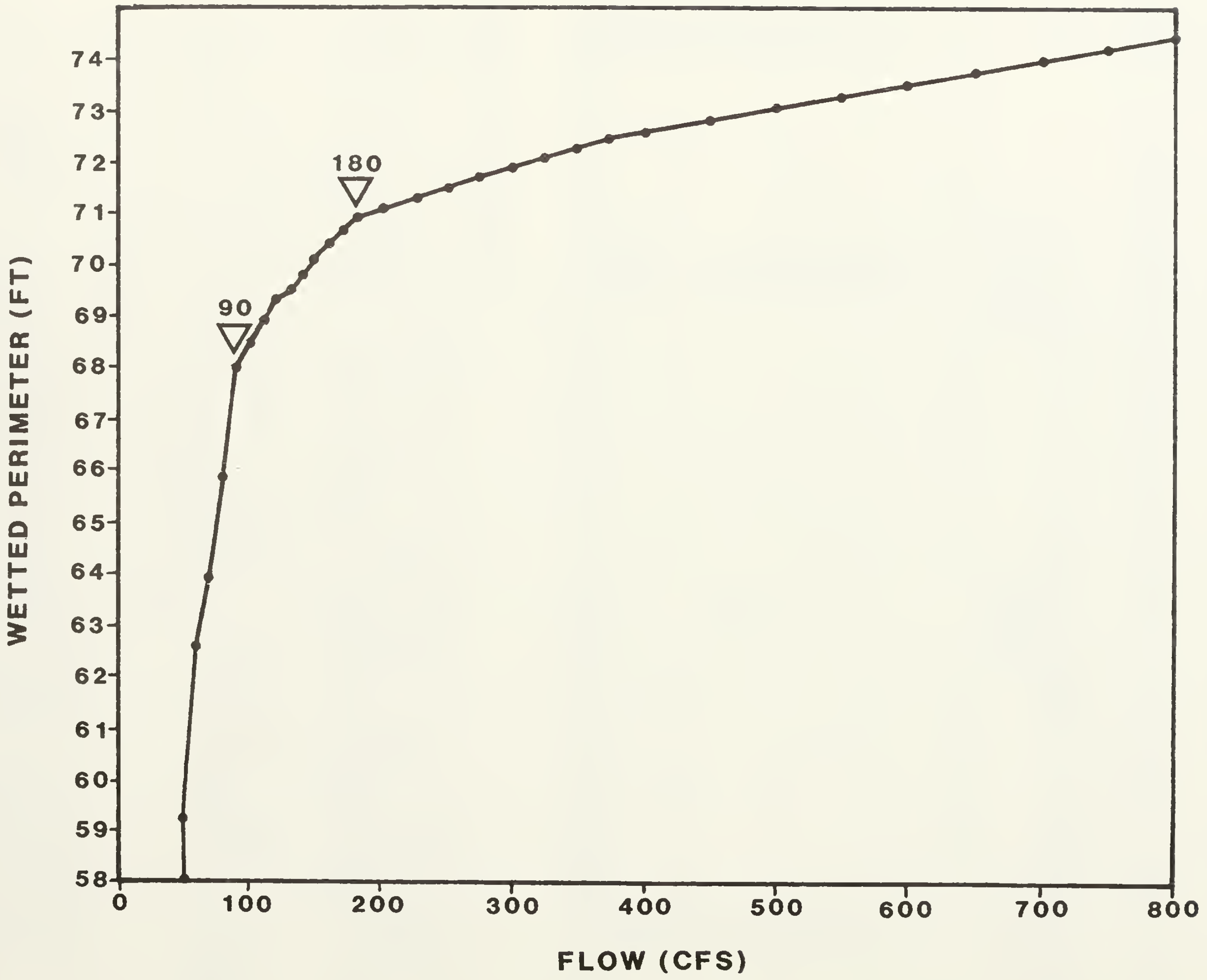

Figure 6. The relationship between wetted perimeter and flow from a composite of 5 riffle/run cross-sections in the Clark Fork River near Deer Lodge.

STREAM NAME: Clark Fork River

STREAM REACH: #2. From the mouth of the Little Blackfoot River to the mouth of Flint Creek - 28.1 miles.

LOCATION: Sec. 23, T9N, R10W to Sec. 31, T11N, R12W

DESCRIPTION OF STREAM REACH:

Major tributaries entering this reach are the Little Blackfoot River and Gold Creek.

Downstream from the Little Blackfoot River at Garrison, the river is confined within a steep, narrow canyon. Bedrock outcrops are common. The increased stream gradient noted at the end of Reach #1 continues until Jens, about halfway through the reach. The steepest gradient, 23.0 feet/mile, is found in the first two miles below Garrison. The Clark Fork River's channel between Garrison and Jens has been shortened by the construction of two major highways and railroads. In many places, riprap has replaced riparian vegetation, and several natural meanders have been severed from the river.

Below Jens the river meanders away from the major transportation corridors and streambank and channel alterations are minimal. Some grazing of riparian vegetation by livestock has occurred, but trout habitat is generally good. The reappearance of alluvial deposits and a meandering channel between Jens and Drummond is reminiscent of the Deer Lodge valley. Channel widths at or near recommended flows are approximately 100 feet at both Gold Creek and Drummond (Peters 1980).

Ray (1983) noted that floodplain sediments collected near Drummond contained concentrations of metals that are as high or higher than those found upstream near Garrison, Racetrack and Rocker. Metal contamination remains the most significant water quality problem in this reach, although irrigation withdrawals and degraded return flows also affect the trout fishery.

The riparian vegetation between Garrison and Drummond, including the Little Blackfoot drainage, is structurally more diverse than the riparian vegetation between Warm Springs and Garrison. A closed canopy forest of cottonwoods forms the uppermost vegetational tier. Willows, river birch, redosier dogwood (*Cornus stolonifera*), rose (*Rosa* spp.) and chokecherry (*Prunus virginiana*) form a shrub-dominated stratum. Understory vegetation is similar to the Warm Springs to Garrison reach in that introduced grasses occur in abundance [Quackgrass (*Agropyron repens*) Kentucky bluegrass, smooth brome and redtop]. Forb diversity appears to increase in this river reach as compared to the adjacent upper reach. Livestock grazing and hay meadows are the predominant agricultural uses of the riparian area.

GAME FISH SPECIES PRESENT: Brown trout, rainbow trout, cutthroat trout, bull trout, mountain whitefish

FISHERY:

The brown trout is by far the most abundant game fish in this reach. Although other trout species are present, they are insignificant in fishery value at this time. Sculpins, normally an important trout food source, are common in the reach.

Five trout population estimates were made at Phosphate, about five miles below Garrison, from 1978 through 1982. One estimate was made between Gold Creek and Jens in 1969 and two estimates were made about four miles above Drummond in 1972 (Table 4). Examination of these data reveals that the reduced trout populations that were found in the Williams-Tavenner and Sager Lane sections of Reach #1 continue to exist throughout Reach #2.

Table 4. Estimated numbers of all trout species per mile in the Phosphate, Gold Creek and Drummond sections.

	Phosphate	Gold Creek	Drummond	
Year	Summer	Summer	Spring	Summer
1969		499		
1972			248	127
1978	269			
1979	496			
1980	315			
1981	225			
1982	174			

WILDLIFE:

Whitetail and mule deer utilize the riparian areas of this reach. Elk also are found along much of the floodplain between Jens and Drummond, particularly in the vicinity of the Wallace Ranch. As in Reach #1, three species of furbearers (beaver, mink, and muskrat) are present in this reach also, as are several species of waterfowl. Bald eagles have been observed during the winter between Garrison and Gold Creek.

WETTED PERIMETER:

Cross-sectional measurements were made in an approximate 800-foot section of Reach #2 near the Gold Creek rest area (SW Sec. 5, T9N, R10W). Three riffle cross-sections were established. The WETP program was calibrated to field data collected at flows of 118.0 and 445.0 cfs.

The relationship between wetted perimeter and flow from a composite of the three riffle cross-sections is shown in Figure 7. Lower and upper inflection points occur at approximate flows of 200 and 400 cfs, respectively.

WHY FLOW IS NECESSARY:

The requested flow is necessary to maintain the physical habitat for existing resident and migratory trout populations, and to make flows available for trout species which are currently absent or present in reduced numbers, but which could become better established if water quality is improved through mining waste reclamation; and to contribute to the maintenance of habitat conditions for those wildlife species which depend upon the stream and its riparian zone for their food, water, and shelter.

FLOW REQUEST:

January 1 - December 31--400 cfs (289,587 A.F./yr)

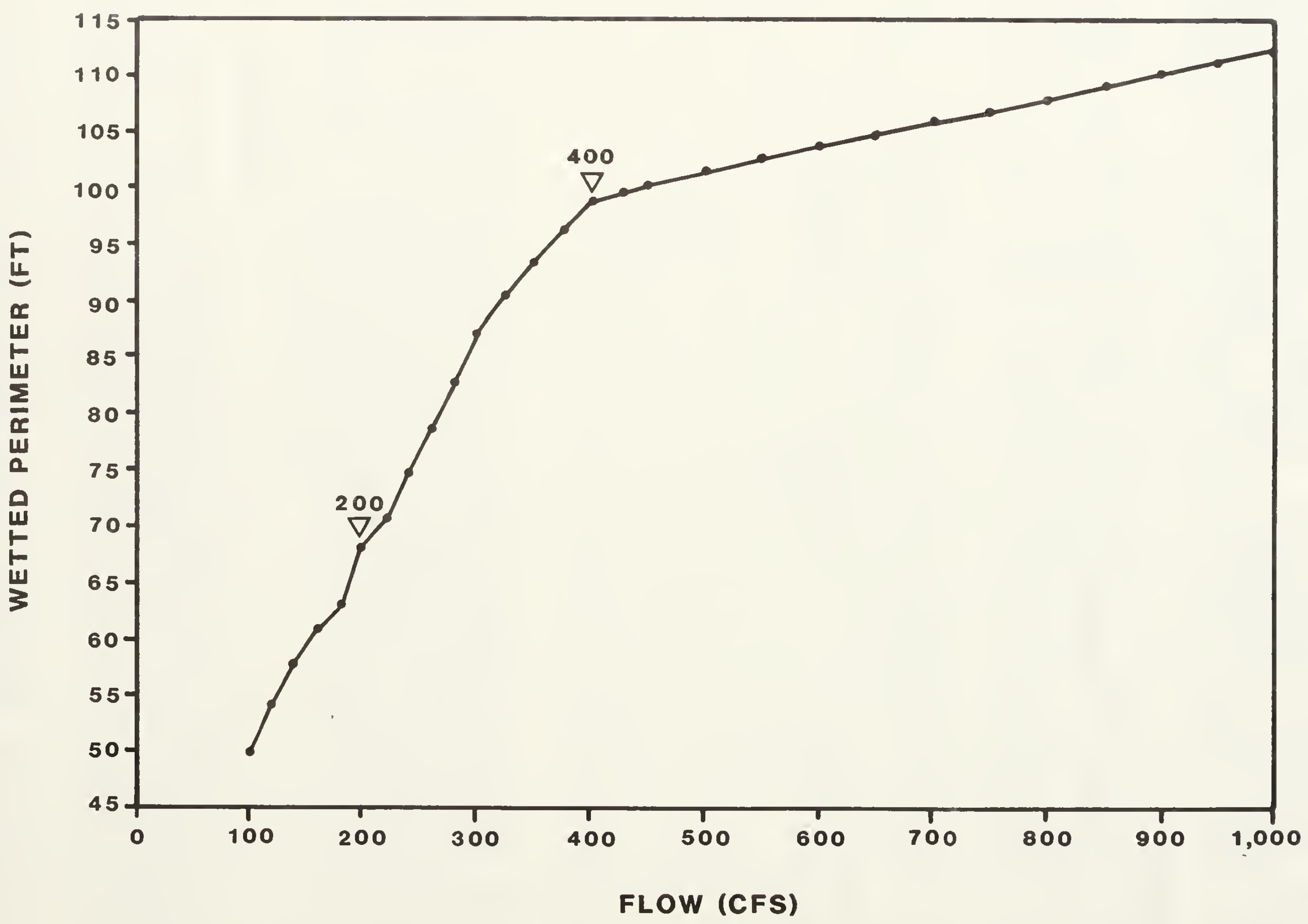

Figure 7. The relationship between wetted perimeter and flow from a composite of 3 riffle cross-sections in the Clark Fork River near Gold Creek.

STREAM NAME: Clark Fork River

STREAM REACH: #3. From the mouth of Flint Creek to the mouth of Rock Creek 35.8 miles.

LOCATION: Sec. 31, T11N, R12E to Sec. 12, T11N, R17W

DESCRIPTION OF STREAM REACH:

Reach #3 begins at Flint Creek near Drummond and extends downstream to the confluence with Rock Creek. Major tributaries entering the Clark Fork within this reach are Flint Creek and Harvey Creek. At least three warm spring sloughs discharge into the river between Bearmouth and Nimrod.

Poorly sorted alluvial fill is present in the floodplain for the first three miles of this reach. The river is then confined within the Bearmouth Canyon until reaching Beavertail Hill, about seven miles above the confluence of Rock Creek. The steepest stream gradient (about 18 feet/mile), is found just above Beavertail Hill, where construction of the Northern Pacific Railroad eliminated a very large oxbow. Several other meanders have also been eliminated within the Bearmouth Canyon by both railroad and highway construction activities. Two artificial meanders were built in an attempt to mitigate eight separate channel changes that occurred during the construction of Interstate 90. These artificial meanders are located in Section 16, T11N, R13W and in Section 17, T11N, R14W (Hunt and Graham 1972). The channel width of the stream near Bearmouth is approximately 100 feet at, or near, the recommended flows.

Metal concentrations that exceed recommended instream levels (EPA 1980) are frequently present in this reach, particularly during high stream flow conditions (Water Quality Bureau 1984). This reach experiences the cummulative effects of upstream water depletions and natural thermal spring contributions of warm water to the Clark Fork. The section also carries a very heavy load of fine sediment, as evidenced by its accumulation on point bars and in slow water areas.

The topography between Drummond and Rock Creek changes from a relatively wide alluvial floodplain to a narrow mountain valley. Because of this narrow valley, land use conflicts between utility corridors, agriculture, recreation, and residential development have developed. The native vegetation has, subsequently, been eliminated from most floodplain areas and occurs primarily as a "green belt" along the river. Mature cottonwoods with understory of shrubs, grasses, and forbs occur immediately adjacent to the river. Where the native vegetation has been relatively unaltered, montane plant species [e.g., ponderosa pine (Pinus ponderosa) and Rocky Mountain juniper (Juniperus scopulorum)] begin to appear as consistent members of the riparian environment.

Alluvial material transported by side drainages into the Clark Fork creates well-drained soil conditions adjacent to the floodplain which allows for the growth of those plant species adapted to drier moisture regimes. The potential vegetational diversity of the narrow valley of the Clark Fork is high as a result of the diverse topography, landforms and exposures that occur in close proximity to the river.

GAME FISH SPECIES PRESENT: Brown trout, rainbow trout, cutthroat trout, bull trout, largemouth bass, mountain whitefish

FISHERY:

Fish population estimates reveal a dramatically smaller trout population in this reach than in the other reaches of the upper Clark Fork (Tables 4, 5, & 6). Four (4) population estimates made at Bearmouth and Bonita showed less than 70 trout per mile. The brown trout is the most abundant trout in the reach, however, rainbow and cutthroat trout are found in greater numbers than in reaches #1 and #2. Species composition averages 66 percent brown, 19 percent rainbow and 15 percent cutthroat trout. Recruitment of new fish into the population appears to be a problem. No juvenile brown or rainbow trout were found in the 1985 spring electrofishing samples. Sculpins, normally an important trout food source, have not been found in this reach.

Table 5. Estimated numbers of all trout species per mile in the Bearmouth and Bonita sections.

	Bearmouth		Bonita	
Year	Spring/Summer	Fall	Spring/Summer	Fall
1979		50	54	123
1985	48			

Although physical habitat constraints affect the trout populations of this reach to some extent, it is significant to note that much of the Bonita section is located away from the major transportation corridors. Also, experience with sampling the types of habitat that occur in this reach leads to the conclusion that the physical habitat is greatly under-utilized, and the low trout populations are a result of water quality problems. The resuspension of metals from the floodplain during periods of high flow appears to cause this severe impact.

WILDLIFE:

Osprey nesting has been documented near Bearmouth. Waterfowl utilize both the mainstem and the numerous isolated river channels and warm spring sloughs of this reach. Beaver, muskrat and mink use the watercourse, and whitetail and mule deer are found in the riparian zones. Bald eagles utilize the river corridor near Bearmouth during the winter.

WETTED PERIMETER:

Cross-sectional measurements for use in the wetted perimeter/inflection point method were made in an approximate 170-foot section of Reach #3 located at the I90 Bearmouth Rest Area (SE, Sec. 15, T11N, R14W). Three riffle cross-sections were established in this section. The WETP program was calibrated to field data collected at flows of 237.4 and 628.2 cfs.

The relationship between wetted perimeter and flow from a composite of the three riffle cross-sections is shown in Figure 8. Lower and upper inflection points occur at approximate flows of 180 and 500 cfs, respectively.

WHY FLOW IS NECESSARY:

The requested flow is necessary to: (1) Maintain the physical habitat for those resident trout populations which currently exist, and to provide adequate flows for future populations which could become established if water quality problems are solved. This section of the Clark Fork could produce significantly more gamefish if water quality problems are solved. Very few streams in Montana have the potential for such a large increase in production than does the Clark Fork; and, (2) contribute to the maintenance of habitat for those wildlife species which depend upon the stream and its riparian zone for their food, water and shelter.

FLOW REQUEST:

January 1 - December 31--500 cfs (361, 983 A.F./yr)

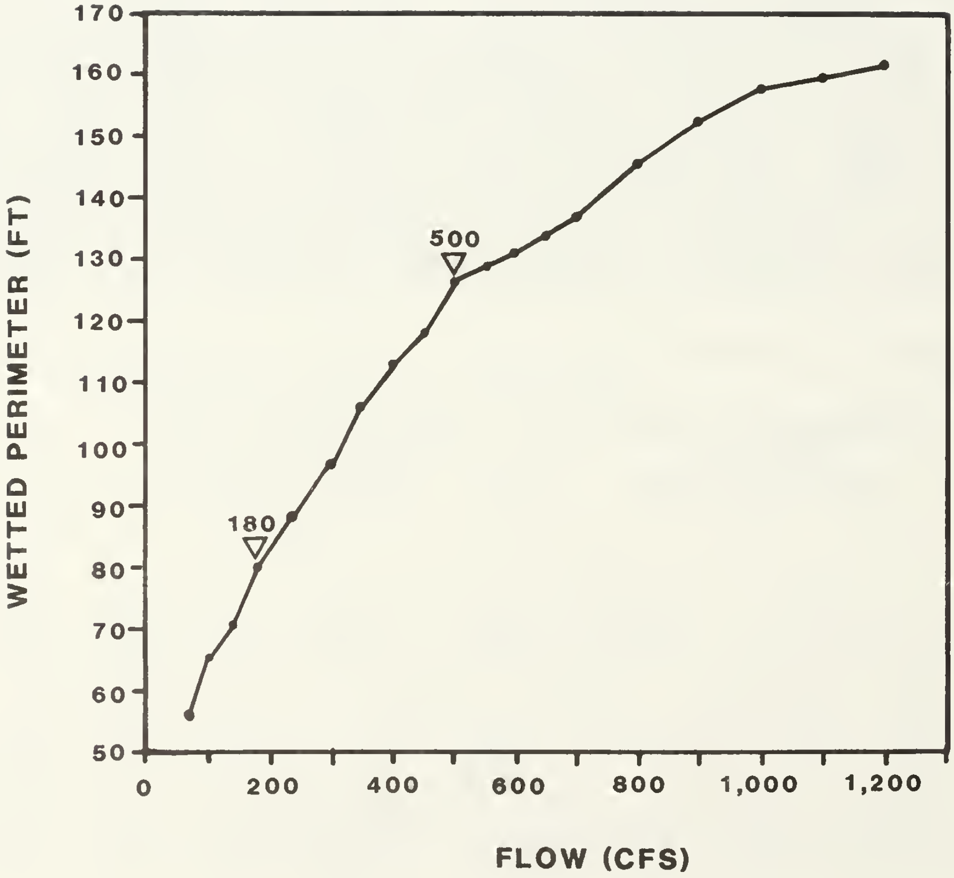

Figure 8. The relationship between wetted perimeter and flow from a composite of 3 riffle cross-sections in the Clark Fork River near Bearmouth.

STREAM NAME: Clark Fork River

STREAM REACH: #4. From the mouth of Rock Creek to the mouth of the Blackfoot River at Milltown Dam - 17.2 miles.

LOCATION: Sec. 12, T11N, R17W to Sec. 21, T13N, R18W

DESCRIPTION OF STREAM REACH:

Beginning at the confluence of Rock Creek, an important major tributary, and terminating at the Milltown Reservoir, this is the lower most and widest (150 feet at or near recommended flows) of the four upper Clark Fork River reaches. The Blackfoot River converges with the Clark Fork within the reservoir at Milltown.

Most of this reach of the river has not been altered by man's activities. There are some channel alterations, but most of these are found in the lowermost stretch from Turah to Milltown Reservoir. Numerous flood channels and deposition areas are evident. Channel gradients are high compared to the upstream reaches, averaging 16.6 feet/mile (Ganser 1983). The steepest gradient, 25 feet/mile, is found above the Turah bridge, where the river has been straightened and riprapped over a distance of nearly two miles. Other streambank and channel alterations, caused primarily by railroad construction, are visible from Turah to Clinton. Milltown Dam has had an impact on stream channel hydraulics of the lower end of this reach; channel braiding is evident for over two miles above Milltown Reservoir.

Natural stream features and processes dominate this stretch of the river although some sections have been rip-rapped to protect highway and railroad embankments. The valley bottom ranges from 0.25 to 1.0 mile wide. The Clark Fork follows a route primarily along the south side of the valley, butting against solid bedrock walls in several places. Despite some land use conflicts, there has not been a major attempt to stabilize the streambanks. In one section, the channel has moved approximately one-quarter mile to the southwest.

Dense cottonwood and aspen trees as well as woody shrubs dominate the natural areas, while open cottonwood stands and grassland dominate the developed grazing lands. Mature cottonwoods are the principal visual feature and serve to maintain the aesthetic quality of the reach of the river. Well-developed canopies of shrub and young trees provide excellent wildlife habitat. Willows are the dominant shrubs, but diversity is provided by rose, chokecherry, snowberry (Symphoricarpos albus), gooseberry (Ribes sp.), mountain maple (Acer glabrum) and elderberry (Sambucus spp.). Forb and grass cover are provided by both introduced and native species, with numerous pioneer and weed species occurring on gravel bars and disturbed sites.

GAME FISH SPECIES PRESENT: Brown trout, rainbow trout, cutthroat trout, bull trout, largemouth bass, mountain whitefish

FISHERY:

Despite major impacts to the riparian zone and river channel, habitat for trout is fairly good, particularly above Clinton and below Turah. Fish population information is available on one section within this reach, extending from the Turah access site downstream for 2.1 miles. This section has been sampled annually since 1979. The section is highly impacted by channel changes and bedload deposition, probably the result of a two-mile long channel straightening immediately upstream. In spite of this, however, trout populations are improved over adjacent upstream sections; a five-fold increase in trout numbers is measurable when compared to the Bearmouth and Bonita sections estimates (Tables 5 & 6). Sculpins, normally an important trout food source, have not been found in this reach.

Table 6. Estimated numbers of all trout species per mile in the Turah section.

Year	Spring/Summer	Fall
1979	425	440
1980		339
1981	346	
1982	371	
1983	309	
1984	479	
1985	311	

Brown trout comprise approximately 53 percent of the total trout population. Rainbow trout follow closely with 45 percent. A few cutthroat, brook, and bull trout are also present. Trout populations ranged from 309 to 479 fish per mile, with a high percentage of the individuals exceeding 12 inches in length. Considerably more juvenile trout of all species are found in this section than in the Bearmouth and Bonita sections. Inflow of cold, clean water from Rock Creek, a "cleaner" substrate, and enhanced streamflow are factors contributing to the improved fishery in this reach.

This reach is used extensively for float fishing, with trips usually beginning at the Schwartz Creek bridge and ending at the Turah access site. The majority of the 14,169 fisherman days of effort reported in the DFWP 1984-85 fishing pressure survey on the Clark Fork between the Bitterroot River and the Little Blackfoot River are probably from this reach.

Some non-point runoff from logging and agricultural areas occurs in this reach, but, as with the rest of the upper Clark Fork, the most measurable and persistent impact to the fishery appears to be caused by metals. Safe instream levels for copper (EPA 1980) are often exceeded during runoff in this reach (Water Quality Bureau 1984).

WILDLIFE:

Bald eagles utilize the upper end of the reach as a feeding area during the winter. Osprey nest along the river near Clinton. Waterfowl, including Canada geese, also nest in the reach. The largest concentrations of waterfowl are on and immediately above Milltown Reservoir. Beaver, muskrat and mink inhabit much of the reach, and whitetail and mule deer are common within the riparian zone.

WETTED PERIMETER:

Cross-sectional measurements used in the wetted perimeter/inflection point method were made in an approximate 123-foot river section downstream from the bridge located about one mile upstream from Turah (SE¼, Sec. 2, T12N, R18W). Three riffle cross-sections were established in this section. The WETP program was calibrated to field data collected at flows of 499 and 1,597 cfs.

The relationship between wetted perimeter and flow from a composite of the three riffle cross-sections is shown in Figure 9. Lower and upper inflection points occur at approximate flows of 300 and 600 cfs, respectively.

WHY FLOW IS NECESSARY:

The requested flow is necessary to: (1) maintain the physical habitat for resident trout populations which currently exist, and to provide adequate flows for future populations which could become established if water quality problems are solved. This stretch of the Clark Fork supports a significant recreational fishery of between 400 and 800 fishermen per mile per year (based upon the 1984-85 DFWP fishing pressure survey). Float fishing in this section is relatively heavy at times and flows suitable for the fishery also provide floaters with adequate clearance over riffle areas; and (2) to contribute to the maintenance of habitat conditions for those wildlife species which depend upon the stream and its riparian zone for food, water, and shelter.

FLOW REQUEST:

January 1 - December 31--600 cfs (434,380 A.F./yr)

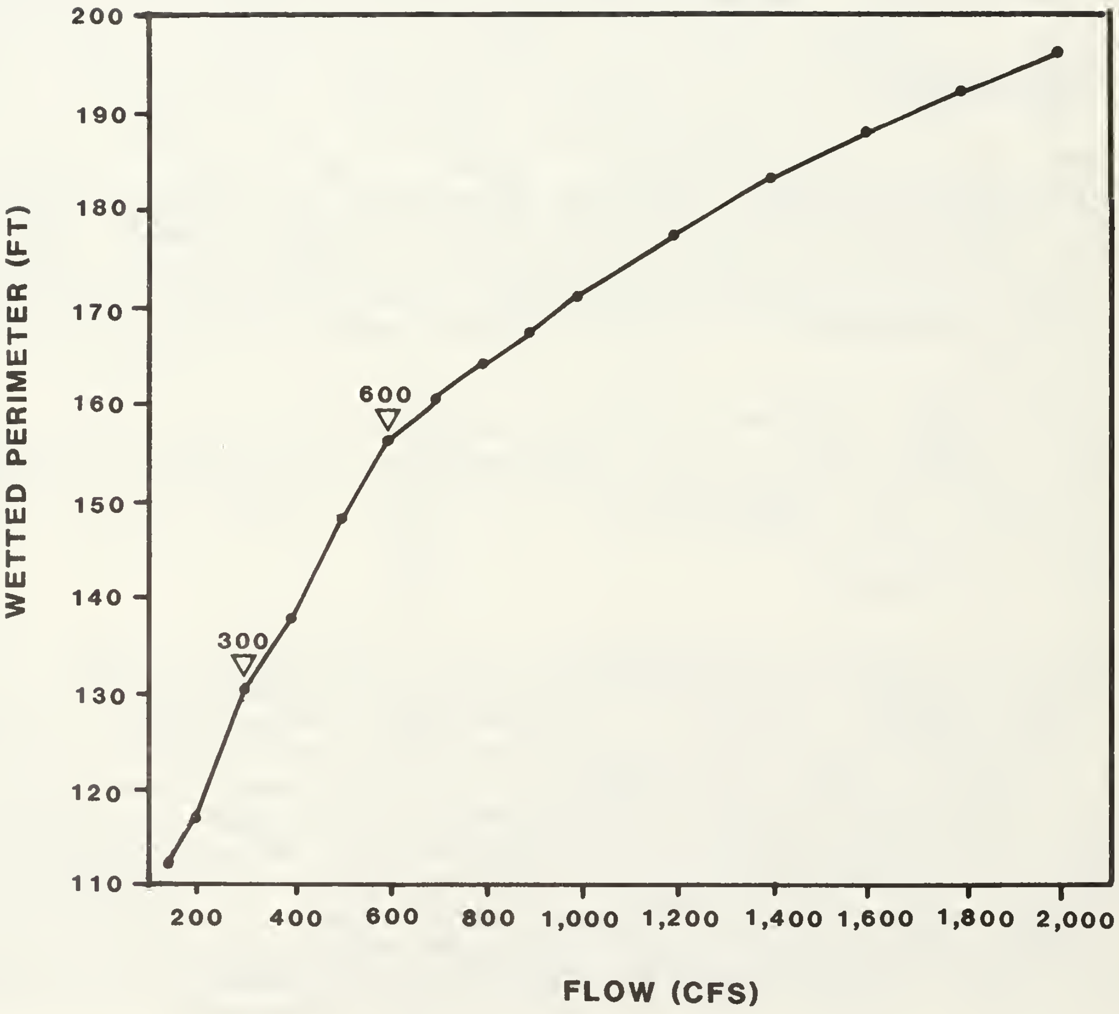

Figure 9. The relationship between wetted perimeter and flow from a composite of 3 riffle cross-sections in the Clark Fork River near Turah.

STREAM NAME: Warm Springs Creek

DESCRIPTION OF THE BASIN:

Warm Springs Creek receives the waters from the north face of the Continental Divide west of Anaconda and the southern drainages of the Flint Creek Range. The main creek begins in the southern Flint Creek Range and flows generally south to Highway 10A before turning eastward to Anaconda. From Anaconda, the stream runs northeast to its confluence with the Clark Fork, 3/4 mile east of the community of Warm Springs (Figure 10). Tributaries of major significance to Warm Springs Creek include Barker Creek, Twin Lakes Creek, Storm Lake Creek and Cable Creek. Lakes in the basin are Hearst, Haggin, Upper and Lower Barker, Lake of the Isles, Upper and Lower Twin, Four Mile Basin, Storm and Silver.

The upper reaches of the Warm Springs basin are described under the sections covering its major tributaries. The steeper, more mountainous reaches end at Highway 10A. The stream from that point to Anaconda flows through a rather restricted valley with a moderate gradient. From Anaconda to its mouth, the gradient is more gentle, and the stream becomes more sinuous. Riparian vegetation is generally well established along the creek and the stream channel is stable over most of its course.

Human activity in the basin is extensive and diverse. Logging, ranching, industry, recreation, transportation, residential and urban activities are established in the Warm Springs drainage. Negative impacts to the stream system have been least in the headwaters and most severe toward the mouth. Logging has been moderate in recent years. Agricultural impacts have been relatively mild upstream from Anaconda with only isolated instances of overgrazing and consequent stream habitat destruction. Recreational use of the basin is heavy, but impacts on the fishery are surprisingly light considering the quality of the resource and ease of access. Urban and dispersed residential developments have not been major detriments to the welfare of the system. Some impacts resulting from sewage disposal occur, and drainage patterns have been altered.

Transportation corridors have been a serious negative impact to Warm Springs Creek. In the headwaters, logging and access roads have caused increased siltation and changes in runoff patterns. The highway system has also caused serious impacts. Along Highway 10A west of Anaconda, a considerable amount of channel straightening has occurred, with consequent loss of habitat, increased erosion and siltation. Downstream from Anaconda, channel alterations along Interstate 90 and a county road have been made, resulting in accelerated flow velocities, increased erosion, loss of riparian habitat and reduction in stream quality for fishes.

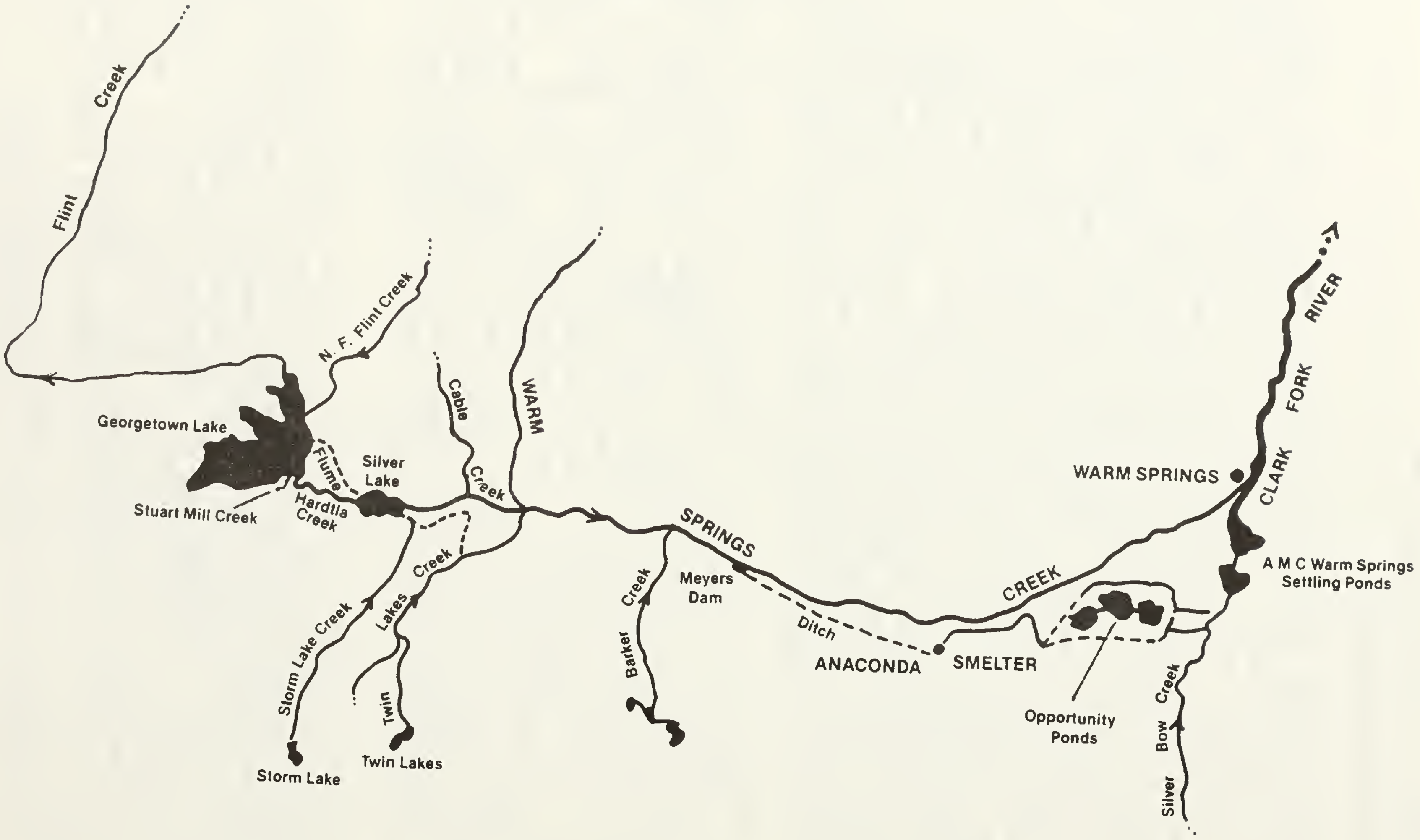

Figure 10. Warm Springs Creek Drainage and Flint Creek.

The major environmental factor affecting Warm Springs Creek has been its industrial use by the Anaconda Minerals Company. The basin has been used as a major source of industrial water for the AMC complexes at Anaconda and Butte. Extensive water system development and manipulation have made fundamental changes in the basin. Storm Lake and Twin Lakes creeks have been diverted in their lower reaches to flow into canals emptying into Silver Lake. Water from Silver Lake may either flow to Georgetown Lake or be released from Silver Lake into Warm Springs Creek. Georgetown Lake water can be pumped back into the Warm Springs system. At Meyers Dam, (an AMC diversion facility three miles west of Anaconda) water may be directed into a pipeline serving Anaconda, the former AMC operation in Anaconda, and a number of localities to the southeast, including the AMC Butte operations, or it may be allowed to continue down Warm Springs Creek. Waters originating in the Warm Springs basin that are diverted to Butte but not consumed, return to the Clark Fork via Silver Bow Creek.

Historically, a major portion of the Warm Springs Creek flow has been removed at Meyers Dam, severely dewatering the stream below. Also, flow has frequently been reduced to zero by an irrigation diversion structure located about 2.5 miles downstream from Anaconda. During periods of low natural streamflow the AMC diversion at Meyers Dam, coupled with the irrigation demand below Anaconda, nearly eliminated the fishery over the remaining 10 or more miles of stream. Even with less withdrawal at Meyers Dam in recent years, the downstream irrigation diversion still severely dewaters Warm Springs Creek during drought years.

Degradation of the downstream ecosystem has been further affected by both air and waterborne pollutants originating from the AMC operations in Anaconda. Airborne materials caused major vegetation destruction in the lower portion of the drainage. Wind transportation of particulate materials from the smelter deposited vast quantities of toxic materials within the lower basin. Pollution discharges via water were extensive, as was the disposal of solid waste products. Both contained components toxic to aquatic ecosystems. Implementation of pollution control regulations reduced the emissions of pollutants from the Anaconda Smelter. The cessation of AMC operations at the Anaconda facility ended the emission of damaging wastes, but the accumulation of toxic materials produced for 100 years remains intact. The extent to which remedial actions can ameliorate the damages is being studied by state and federal agencies (CH_2M Hill 1984).

Streamflow below Meyers Dam increased substantially after water removal by AMC declined. Although agricultural water diversion is still a major impact to downstream environments, the overall flow increase resulted in major improvement to the Warm Springs fishery as well as providing important dilution flows for the Clark Fork. If the advances made in aquatic ecosystem health in lower Warm Springs Creek and the Clark Fork are to be maintained, it is imperative that adequate flow in Warm Springs Creek be maintained. Warm Springs Creek is a major water source for the upper Clark Fork River.

In the first half of 1986, Montana Resources, Inc., a Montana firm, began mining in the Butte area, reopening the former AMC operation on a limited basis. A portion of the water previously diverted by AMC at Meyers Dam for the Butte operation is currently being diverted for the same purpose by Montana Resources, Inc. This has resulted in some renewed effect upon water availability in Warm Springs Creek but not yet of a magnitude equalling that when AMC was diverting the water.

STREAM NAME: Warm Springs Creek

STREAM REACH: #1. From the confluence of the Middle Fork Warm Springs Creek to Meyers Dam - 15.3 miles.

LOCATION: Sec. 20, T6N, R12W to Sec. 25, T5N, R12W

GAME FISH SPECIES PRESENT: Cutthroat trout, bull trout

FISHERY:

The sampled section is in a lodgepole pine bottom. The stream is about 10 feet wide with a moderate gradient. Pool development is good, banks are stable and fish habitat is very good. Stream bank vegetation consists of grass, sedge and some willows. Substrate is cobble and gravel.

Electrofishing revealed the presence of a few bull trout and numerous westslope cutthroat trout. Average fish size is small, consistent with the small stream dimensions. Size may be influenced by angler harvest due to easy access. Juveniles of both species were present as a result of natural reproduction. The population of cutthroat trout over six inches in length was estimated to be 502 fish per mile of stream.

WILDLIFE:

Gamebirds inhabiting this reach of Warm Springs Creek are Franklin's, blue and ruffed grouse. Furbearers are mink, beaver and muskrat. Species of big game include moose, mule deer and elk. Little waterfowl use of Reach #1 occurs.

WETTED PERIMETER:

Cross-sectional measurements were made in a 28-foot section located upstream from Meyers Dam (NE, Sec. 26, T5N, R12W). Three riffle cross-sections were established in this section. The WETP program was calibrated to field data collected at flows of 36.4, 59.1, 60.1 and 165.9 cfs.

The relationship between wetted perimeter and flow from a composite of the three riffle cross-sections is shown in Figure 11. Lower and upper inflection points occur at approximate flows of 24 and 50 cfs, respectively.

WHY FLOW IS NECESSARY:

The requested flow is necessary to maintain trout populations in their existing condition, particularly the rare and sensitive native bull trout; to help assure adequate flow in lower Warm Springs Creek; to help maintain water quality in the Clark Fork

River; and to assist in the maintenance of habitat for those wildlife species which depend upon the stream and riparian zone for their food, water and shelter.

FLOW REQUEST:

January 1 - December 31--50 cfs (36,198 A.F./yr)

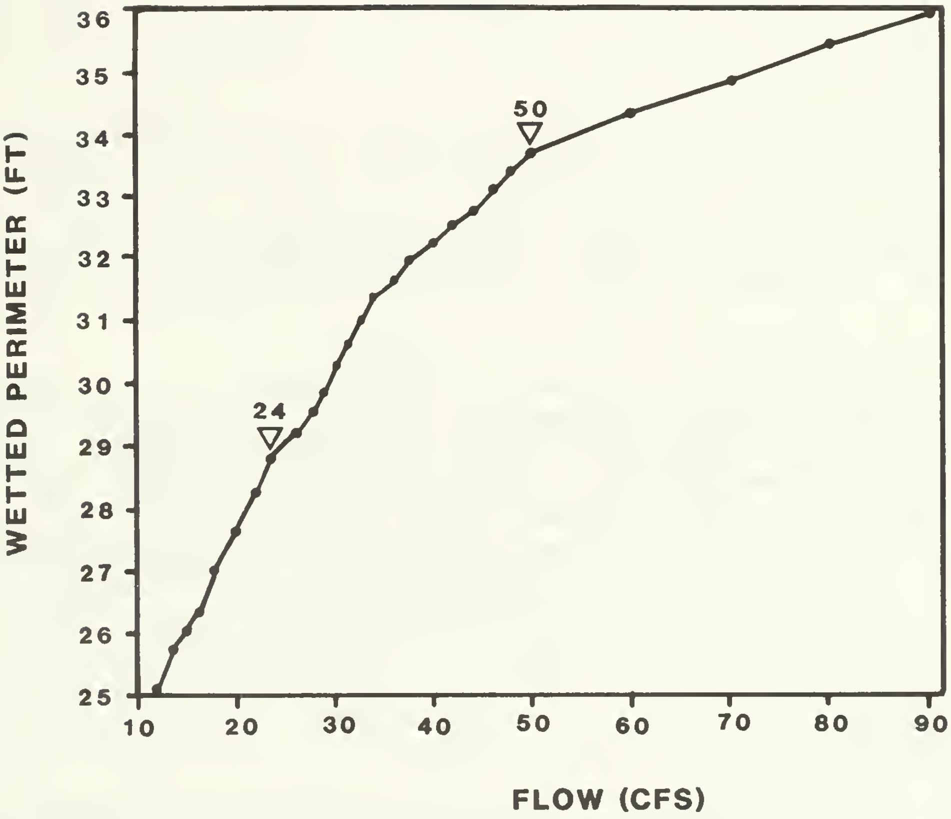

Figure 11. The relationship between wetted perimeter and flow from a composite of 3 riffle cross-sections in Warm Springs Creek above Meyers Dam.

STREAM NAME: Warm Springs Creek

STREAM REACH: #2. From Meyers Dam to the mouth - 16.6 miles.

LOCATION: Sec. 25, T5N, R12W to Sec. 18, T5N, R9W

FISH SPECIES PRESENT: Brown trout, mountain whitefish

FISHERY:

The stream section electrofished is immediately upstream from the Warm Springs State Hospital. The stream is about 15 feet wide, gently meandering, and of low gradient. Riparian vegetation is well established and composed of willow, alder and grasses. A short section is bordered by riprap placed to protect a road bed. Substrate is cobble and gravel and some silt. Habitat quality is good, with well-developed pools and riffles. Bank cover is extensive.

Sampling in the section was carried out in September, 1983. The brown trout population was estimated to be 492 fish per stream mile. A few coarsescale suckers, juvenile and adult whitefish were caught. Juvenile brown trout were common. Brown trout size distribution was good, with a maximum length of 14 inches. The density of the brown trout population is exceptional for so small a stream.

The use of Warm Springs Creek as a spawning site by brown trout from the Clark Fork was assessed in 1983. Since water quality in the Clark Fork does not appear to be suitable for trout reproduction, Warm Springs Creek was considered to be the most likely spawning area for Clark Fork brown trout. To determine the presence and extent of any migration, a trap was established near the mouth of Warm Springs Creek to capture upstream migrants. While electrofishing on the Clark Fork in the summer of 1983, large numbers of brown trout were captured and marked by clipping the adipose fin. This mark was then used to determine if Clark Fork fish ascend Warm Springs Creek during the fall spawning period.

The fish trap was installed on October 8, 1983, and during the succeeding days was operated with great difficulty. On October 18, the trap was removed.

During the period in which the trap was functional, a substantial number of spawning whitefish were captured, presumably migrants from the Clark Fork. The trap captured 41 brown trout. Of the 41, eight (8) had been marked in the Clark Fork. Because the trap was located only a short distance above the junction with the Clark Fork and, due to its design which captured only upstream migrants, it was assumed that all brown trout captured were Clark Fork fish. The ratio of marked to unmarked fish (out of 41 captured) was 8 marked and 33 unmarked.

To expand the trap data and to cover a greater portion of the brown trout spawning season, electrofishing was conducted during the period October 12 to 28 from the mouth upstream to a beaver dam barrier (which has since been removed). This survey resulted in the capture of an additional 62 fish which had been marked in the Clark Fork. The ratio of unmarked to marked fish observed in the trapped fish was 4.1:1. Thus the total of 70 marked fish captured was multiplied by 4.1 to equal an estimated 288 unmarked fish. The 70 marked fish were then added to the 288 fish to give an estimated total of 358 Clark Fork brown trout entering Warm Springs Creek to spawn. This estimate can also be derived as follows:

$$\frac{8}{41} = \frac{62 + 8}{X}$$

$$8X = 2870$$

$$X = 358.8$$

Where:

X = Total estimated number of spawning brown trout.

41 = Total number of brown trout trapped.

8 = Number of marked brown trout trapped.

62 = Number of marked brown trout captured by electrofishing.

The above is probably a substantial underestimate of Clark Fork brown trout spawning use of Warm Springs Creek because sampling was terminated in October and spawning activity continues through November. Thus, fish entering Warm Springs Creek after the sampling was ended would not have been included in the estimate.

Based on the trapping and electrofishing data, it is clear that Warm Springs Creek is an important spawning area for brown trout migrating out of the Clark Fork. Recruitment of young fish from Warm Springs Creek is important in maintaining healthy trout populations in this reach of the Clark Fork.

WILDLIFE:

There is considerable waterfowl use of Reach #2. It provides early and late open-water habitat when other localities are ice-covered.

Big game along lower Warm Springs Creek is predominantly white-tailed deer. A substantial herd occupies riparian habitat in the area. Furbearers which utilize this section are red fox, beaver, mink and muskrat. Grey partridge and ring-necked pheasants are also associated with the stream in this area.

WETTED PERIMETER:

Cross-sectional measurements were made in a 34-foot section of Reach #2 located approximately 0.7 mile upstream from its confluence with the Clark Fork River (SE,SE, Sec. 13, T5N, R10W). Three riffle cross-sections were established in this section. The WETP program was calibrated to field data collected at flows of 31.2, 62.0 and 78.0 cfs.

The relationship between wetted perimeter and flow from a composite of the three riffle cross-sections is shown in Figure 12. Lower and upper inflection points occur at approximate flows of 16 and 40 cfs, respectively. Based on an evaluation of existing fishery information , a flow of 40 cfs is recommended for the maintenance of year-round fish habitat.

WHY FLOW IS NECESSARY:

The requested flow is necessary to maintain the existing resident trout populations; to provide adequate flow for passage, spawning and rearing of migratory species from the Clark Fork; to provide good quality water to the Clark Fork to help in diluting toxic mining wastes; and to assist in the maintenance of habitat for those wildlife species which depend upon the stream and its riparian zone for their food, water and shelter.

FLOW REQUEST:

January 1 - December 31--40 cfs (28,959 A.F./yr.)

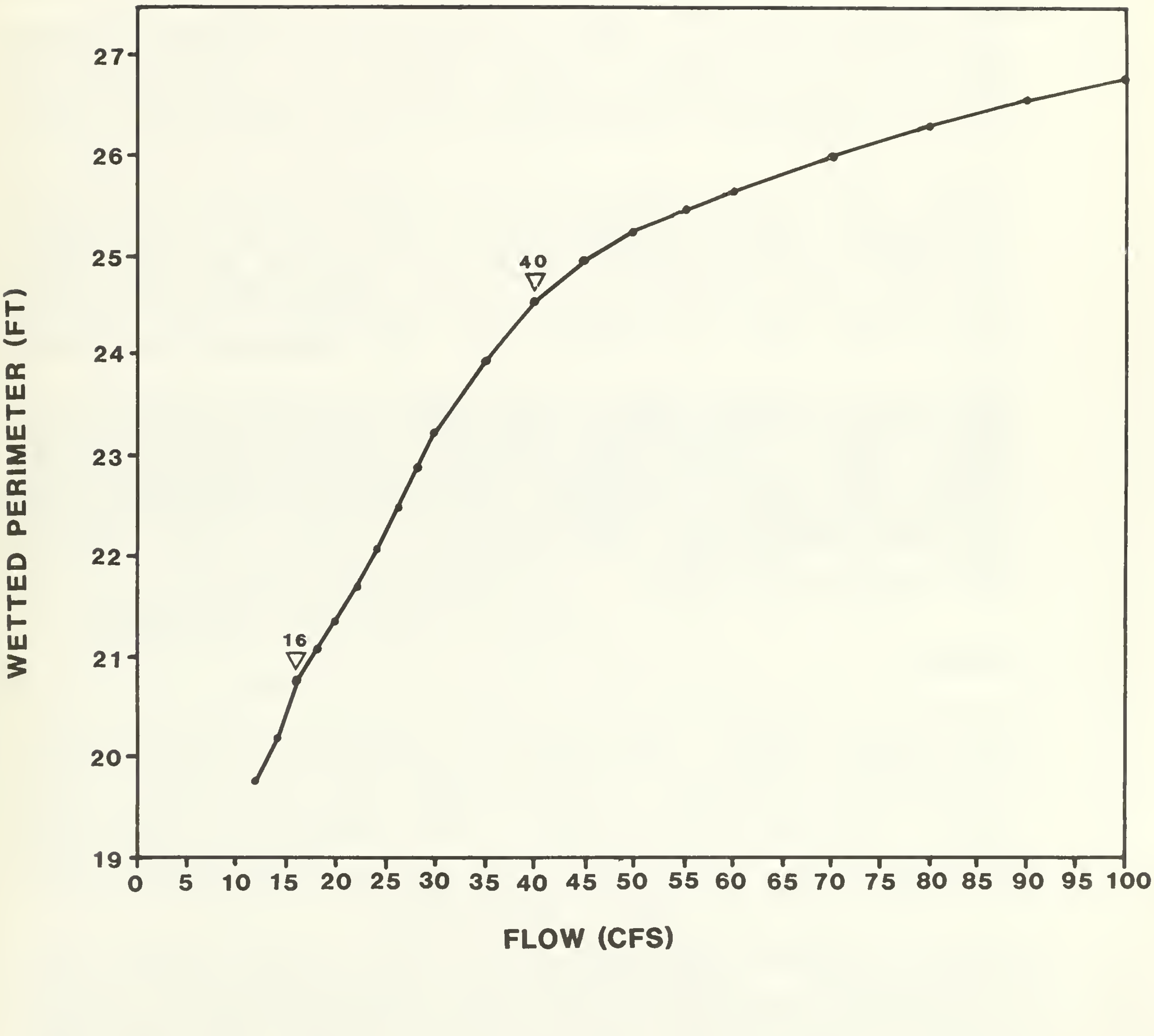

Figure 12. The relationship between wetted perimeter and flow from a composite of 3 riffle cross-sections in Warm Springs Creek near its mouth.

STREAM NAME: Barker Creek

STREAM REACH: From Upper Barker Lake to the mouth - 5.1 miles.

LOCATION: Sec. 17, T4N, R12W to Sec. 28, T5N, R12W

DESCRIPTION OF STREAM REACH:

The origin of Barker Creek is along the Continental Divide approximately 10 miles west of Anaconda. It drains about 14 square miles of mostly timbered mountains. It receives the waters from Nelson Gulch and Upper and Lower Barker Lakes before entering Warm Springs Creek about seven miles west of Anaconda.

Barker Creek flows north. It has a substrate of boulder and rubble and is quite precipitous throughout most of its length. Riparian vegetation is dense and composed of alder, willow, aspen and spruce. The principle uses of the basin are for water production and recreation. The waters from Barker Creek flow down Warm Springs Creek where they may either go into the AMC water supply line or continue down Warm Springs to the Clark Fork.

The Barker Creek drainage is currently in good condition, but logging could have serious deleterious consequences for the system. Part of the value of this stream is its ability to produce bull trout. Increases in siltation or temperature, both typical consequences of logging, could reduce or eliminate the bull trout spawning run.

GAME FISH SPECIES PRESENT: Westslope cutthroat trout, bull trout, rainbow trout, brook trout

FISHERY:

The section sampled was just upstream from the confluence with Warm Springs Creek. The stream in this area is quite steep, cascading over boulders and wind-felled trees. It is split by an island above the mouth. Stream width is about 10 feet, and riparian vegetation is excellent. The substrate is boulder and cobble. Pools are not frequent due to the high gradient, and most fish habitat is in plunge pools and pockets behind boulders. The stream is cold and low in productivity.

Sampling revealed the presence of brook, bull, rainbow and cutthroat trout. A population estimate was attempted but, due to the steepness and swift current, not completed. It is likely that populations are much like Storm Lake Creek. Bull trout were the most abundant species taken. One bull trout was a ripe male 17.3 inches in length, much larger than this environment could be expected to support. This fish was probably a spawner from Warm Springs Creek and was using Barker Creek for reproduction purposes. Physically, Barker Creek appears to be a good quality bull trout spawning stream and this is reflected in the dominance of the trout population by this species.

WILDLIFE:

The Barker Creek environment provides habitat for elk, moose, mule deer, beaver, mink, muskrat, and blue, ruffed and Franklin's grouse. Barker Creek is too small and steep to be of value as waterfowl habitat.

WETTED PERIMETER:

Cross-sectional measurements were made in a 6-foot section of Barker Creek located approximately 0.8 mile upstream from its confluence with Warm Springs Creek (NW,SE,SE, Sec. 29, T5N, R12W). Two riffle cross-sections were established in this section. The WETP program was calibrated to field data collected at flows of 13.5, 17.8 and 29.9 cfs.

The relationship between wetted perimeter and flow from a composite of the two riffle cross-sections is shown in Figure 13. Lower and upper inflection points occur at approximate flows of 9 and 12 cfs, respectively.

WHY FLOW IS NECESSARY:

The requested flow is necessary to maintain resident populations of cutthroat and Bull trout; to provide adequate passage and spawning habitat for bull trout entering from Warm Springs Creek; to provide flows for lower Warm Springs Creek; to provide good quality water to the Clark Fork River to help dilute toxic mining wastes; and to assist in maintenance of habitat for those wildlife species which depend upon the stream and its riparian zone for food, water and shelter.

FLOW REQUEST:

January 1 - December 31--12 cfs (8,688 A.F./yr.)

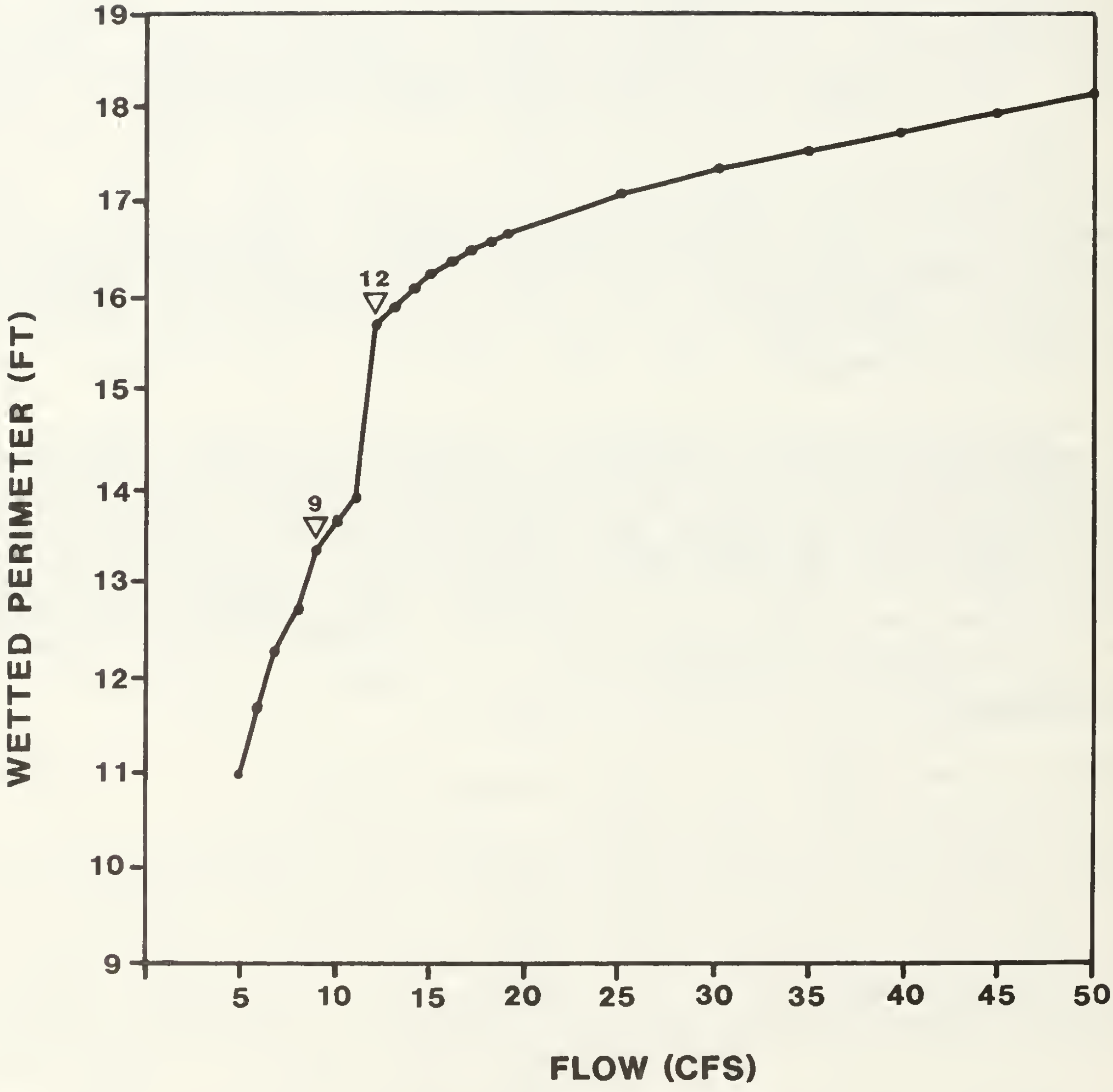

Figure 13. The relationship between wetted perimeter and flow from a composite of 2 riffle cross-sections in Barker Creek.

STREAM NAME: Cable Creek

STREAM REACH: From the headwaters to the mouth - 5.8 miles.

LOCATION: Sec. 3, T5N, R13W to Sec. 19, T5N, R12W

DESCRIPTION OF STREAM REACH:

The Cable Creek drainage is gently mountainous terrain with an extensive meadow section just above the junction with Storm Lake Creek. The upper sections are moderately steep while the lower section is more gentle. Upper section substrate is boulder and rubble, changing to gravel and silt near the mouth. Riparian vegetation is abundant upstream, but downstream segments have been damaged by livestock overuse. Bank stability is consequently reduced, and erosion is moderate to severe in the lower sections.

Agricultural use of the basin is primarily grazing. Logging also occurs, but recreational use is probably the dominant human activity. Water production for the AMC operations in Anaconda and Butte has been an important function of the drainage.

The major negative impacts presently affecting this system are logging and grazing. Bank erosion and damage to riparian vegetation by livestock are moderate to severe.

GAME FISH SPECIES PRESENT: Cutthroat trout, bull trout, rainbow trout, brook trout

FISHERY:

The section electrofished lies just downstream from the confluence of Cable Creek and Silver Lake outlet, about 11 miles west of Anaconda. The section is of low gradient with gravel and silt substrate. Stream width is about 10 feet. Riparian vegetation is willow, some alder, grasses and sedges. Considerable overuse by livestock upstream has damaged the environmental quality of this section. Inadequate streamside woody vegetation has reduced fish cover to undercut banks. Considerable quantities of submerged vegetation occupy the silt substrates. Pool and riffle areas are poorly defined, and the section is basically a long, slow glide.

Electrofishing found rainbow, brook, cutthroat and bull trout and a fair number of sculpins to be present. Bull and cutthroat trout were rare. Brook trout were the most abundant species followed by rainbow trout. Large numbers of juveniles of the latter two species were present.

The fish population was estimated to be 1,197 trout of all species per mile. This locality appears to have the only self-sustaining stream rainbow population in the Warm Springs drainage. In addition to its value as a fishery, the system provides important flows to Warm Springs Creek and the Clark Fork.

WILDLIFE:

Wildlife species occupying stream-associated habitats include beaver, muskrat, and mink, as well as blue, ruffed and Franklin's grouse. Big game species include mule deer, white-tailed deer, moose and elk. The meadow sections of this system provide some habitat to migrant and local waterfowl.

WETTED PERIMETER:

Cross-sectional measurements were made in a 16-foot section of Cable Creek located downstream from its confluence with Storm Lake Creek (SW, NW, SW, Sec. 24, T5N, R13W). Three riffle cross-sections were established in this section.

During the period field measurements were made, flows remained stable at 10.2 to 12.1 cfs. Therefore, the WETP method could not be applied. Annual snowmelt appears to have little influence on flows. The stream is spring fed and likely has a relatively stable flow regime. Three (3) flow measurements were made when streamflow was 10.2, 10.2 and 12.1 cfs, respectively. From these observations, 10 cfs was considered adequate to maintain the fishery.

WHY FLOW IS NECESSARY:

The requested flow is necessary to maintain the stream's self-sustaining resident trout populations; to provide flows for lower Warm Springs Creek; to provide good quality water to dilute toxic wastes in the Clark Fork River; and to assist in maintenance of habitat for those wildlife species which depend upon the stream and its riparian zone for food, water and shelter.

FLOW REQUEST:

January 1 - December 31--10 cfs (7,240 A.F./yr.)

STREAM NAME: Storm Lake Creek

STREAM REACH: From Storm Lake to the mouth - 10.0 miles.

LOCATION: Sec. 30, T4N, R13W to Sec. 23, T5N, R13W

DESCRIPTION OF STREAM REACH:

Storm Lake Creek drains an area of about 10 square miles. The creek begins at Storm Lake, a natural lake near the crest of the Continental Divide whose storage capacity has been increased by the addition of a dam at the outlet. The creek has no major tributaries and drains only the lake, from which it gets its name. It flows in a northerly direction to a flume, where the AMC historically directed its flow into Silver Lake.

The majority of the Storm Lake Creek drainage is timbered mountains. The substrate over the stream course is boulder and rubble and the gradient is steep. Riparian vegetation is well developed and composed of spruce, willow, aspen and alder. The stream is about 10 feet wide. Storm Lake Creek has been channelized in many sections and this has reduced its fishery habitat potential. Storm Lake Creek is cold, precipitous and, hence, relatively unproductive. However, it provides an important flow contribution to Warm Springs Creek and the Clark Fork. Water production and recreation are the major uses in the drainage.

Storm Lake Creek is a portion of the extensive system of water delivery that served the AMC complexes in Anaconda and Butte. Under this system, water from Storm Lake Creek could be diverted through Silver Lake into Georgetown Lake and ultimately to Flint Creek. It could also be released from Silver Lake into the Warm Springs Creek drainage and thence either diverted into the pipeline supplying Anaconda and Butte AMC facilities or allowed to continue down Warm Springs Creek to the Clark Fork. Montana Resources, Inc. reopened the former AMC Butte operations on a limited basis in 1986. The same water delivery system used by AMC is likely being operated by Montana Resources, but on a limited basis at the present time.

If the water from Storm Lake Creek was allowed to follow a natural course to Warm Springs Creek, it would provide a substantial addition of high-quality spawning habitat for that stream system.

GAME FISH SPECIES PRESENT: Cutthroat trout, bull trout, brook trout

FISHERY:

The section sampled lies just upstream from the point at which the stream is diverted into a flume to Silver Lake. Electrofishing yielded brook, bull and cutthroat trout. The population of all species was estimated to be 145 fish per mile. The low density reflects not only the size of the stream but its cold, precipitous nature. Its value as a fishery, although not insignificant, is outweighed by its contribution of flow to the upper Clark Fork via Warm Springs Creek, and, by its potential improvement as a spawning tributary for trout from Warm Springs Creek. This improvement is possible if the diversion into Silver Lake is discontinued and the water allowed to flow downstream into Warm Springs Creek.

WILDLIFE:

Gamebird use is by blue, ruffed, and Franklin's grouse. Furbearers include beaver, muskrat and mink. Species of big game utilizing Storm Lake Creek habitats include elk, moose and mule deer.

WETTED PERIMETER:

Cross-sectional measurements were made in a 26-foot section of Storm Lake Creek located in NE, SW, NW, Sec. 34, T5N, R13W. Two riffle cross-sections were established in this section. The WETP program was calibrated to field data collected at flows of 12.6, 16.1 and 26.3 cfs.

The relationship between wetted perimeter and flow from a composite of the two riffle cross-sections is shown in Figure 14. Lower and upper inflection points occur at approximate flows of 3 and 10 cfs, respectively.

Based strictly on an evaluation of existing resident fishery values, and assuming a continuance of the historical operation and diversion patterns, a flow of 3 cfs is recommended. With the termination of the AMC operations, it is possible that Storm Lake Creek could remain in its natural channel to its confluence with Cable Creek. If this occurs, a flow of 10 cfs is recommended to improve the potential spawning and rearing habitats for migratory trout species and for additional flow contribution to the lower reaches of Warm Springs Creek.

WHY FLOW IS NECESSARY:

The requested flow is necessary to maintain the existing resident trout population; to improve the spawning potential for migratory species from Warm Springs Creek; to provide flows for Warm Springs Creek; to provide good quality water to the Clark Fork River to dilute toxic pollutants in that stream; and to assist in maintenance of habitat for those species of wildlife which depend upon the stream and its riparian zone for food, water and shelter.

FLOW REQUEST:

With historical (diversion) flow pattern:

January 1 - December 31--3 cfs (2,172 A.F./yr.)

With natural (non-diversion) flow pattern:

January 1 - December 31--10 cfs (7,240 A.F./yr.)

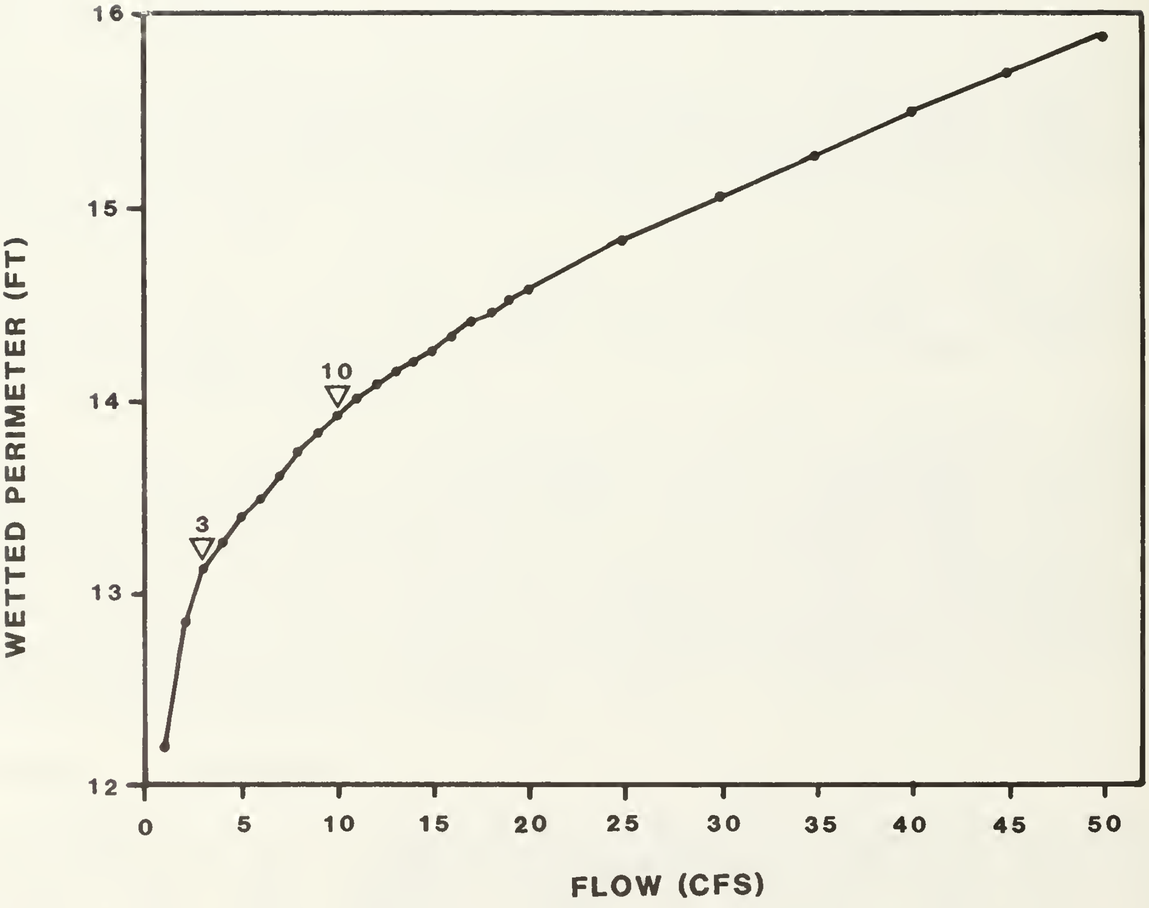

Figure 14. The relationship between wetted perimeter and flow from a composite of 2 riffle cross-sections in Storm Lake Creek.

STREAM NAME: Twin Lakes Creek

STREAM REACH: From Lower Twin Lake to the mouth - 7.5 miles.

LOCATION: Sec. 22, T4N, R13W to Sec. 19, T5N, R12W

DESCRIPTION OF STREAM REACH:

Twin Lakes Creek drains an area of 22 square miles on the north side of the Continental Divide west of Anaconda. Its course is generally to the north, where it enters Warm Springs Creek about 10 miles west of Anaconda.

The majority of the creek's course is in steep, timbered mountains. Substrate is mostly boulder and rubble with gravel interspersion. Riparian habitats are in good condition and are mainly composed of spruce, alder, aspen and willow. Twin Lakes Creek drains the Four Mile Basin Lakes, Lake of the Isles, as well as the lakes from which its name is taken. The stream achieves a 15-foot width in the lower sections and water transparency is quite high; this factor, coupled with the rather steep gradient, provides a high scenic value.

Land use in the basin is for water production and outdoor recreation. The basin is presently in excellent condition. Threats to its future are most likely to arise from recreational home development and logging. The latter seems most probable.

GAME FISH SPECIES PRESENT: Westslope cutthroat trout, bull trout, brook trout, brook/bull trout hybrid

FISHERY:

A section of Twin Lakes Creek just above its confluence with Warm Springs Creek was sampled in 1983. The section is in good condition, with stable banks well vegetated with alder, spruce, aspen and willow. Substrate is rubble and gravel. Cover is provided by overhanging vegetation as well as instream features. The gradient is moderate. A beaver dam is located at the lower end of the section.

Fishes inhabiting Twin Lakes Creek include westslope cutthroat, brook and bull trout and brook X bull hybrids. The population is mostly cutthroats, but bull trout numbers are also high. Brook trout and brook X bull trout hybrids were a small fraction of the population. The estimated number of 6-inch or larger trout of all species was 880 fish per mile. This level of production is extremely high for so small a creek. It is probable that fish from Warm Springs Creek ascend Twin Lakes Creek to spawn. The presence of young bull trout emphasizes the high environmental quality of the drainage and its value as habitat for this very sensitive and declining native gamefish.

WILDLIFE:

Twin Lakes Creek provides habitat for mink, muskrat and beaver. The riparian zones along the stream are used by elk, moose, mule and white-tailed deer. Game birds using the area are blue, Franklin's, and ruffed grouse.

Since Twin Lakes Creek is small and steep over most of its length, it is not likely to provide significant waterfowl habitat.

WETTED PERIMETER:

Cross-sectional measurements were made in a 38-foot section of Twin Lakes Creek located near its confluence with Warm Springs Creek (NW, SE, SW, Sec. 19, T5N, R12W). Three riffle cross-sections were established in this section. The WETP program was calibrated to field data collected at flows of 12.4, 17.6 and 32.6 cfs.

The relationship between wetted perimeter and flow from a composite of the three riffle cross-sections is shown in Figure 15. Lower and upper inflection points occur at approximate flows of 7 and 13 cfs, respectively.

WHY FLOW IS NECESSARY:

The requested flow is necessary to maintain the excellent resident trout populations, particularly the very sensitive and declining native bull trout; to provide high quality flows to Warm Springs Creek; to provide good quality water to the Clark Fork River to dilute toxic pollutants; and to assist in maintenance of habitat for those wildlife species which depend upon the stream and its riparian zone for food, water and shelter.

FLOW REQUEST:

January 1 - December 31--13 cfs (9,412 A.F./yr.)

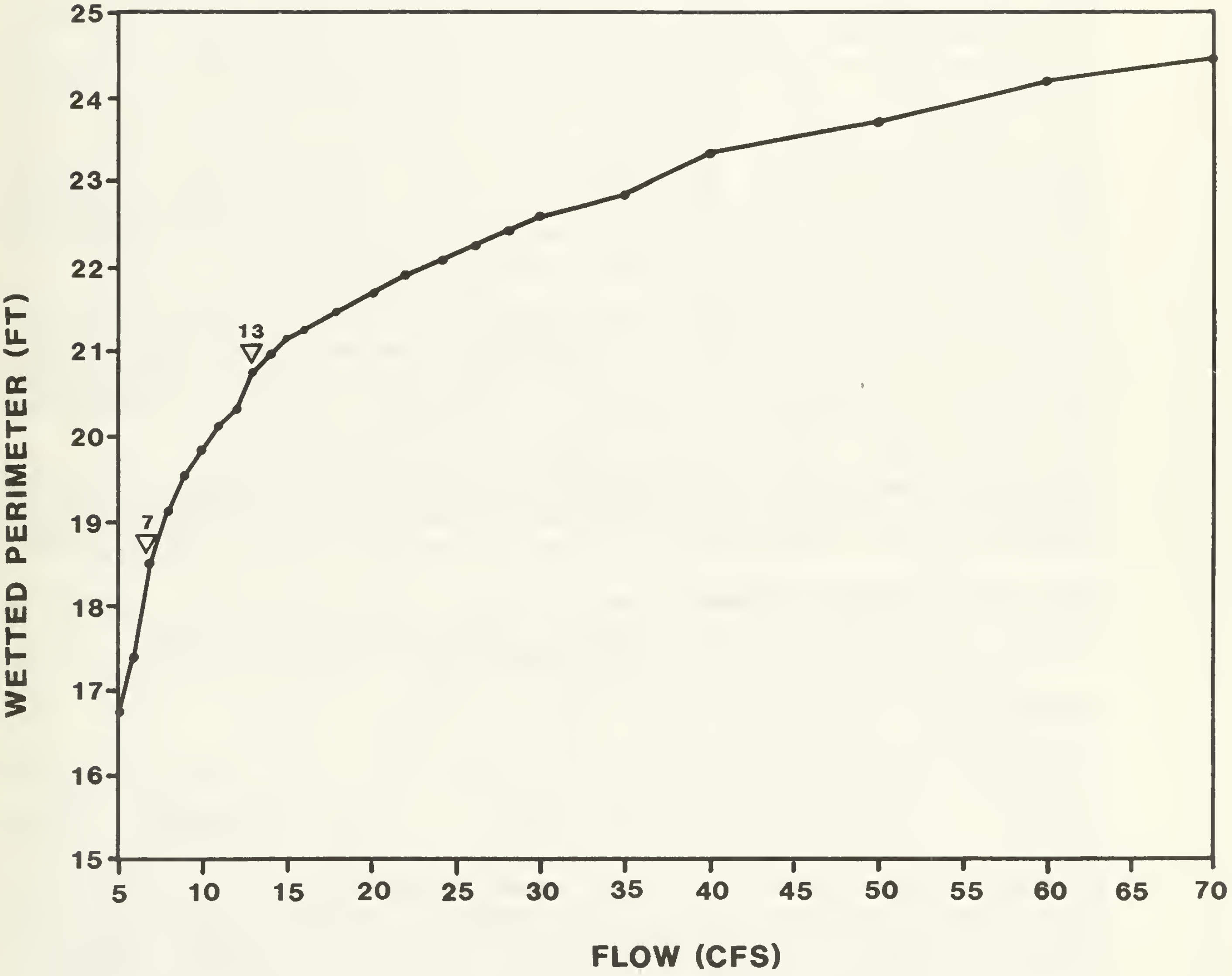

Figure 15. The relationship between wetted perimeter and flow from a composite of 3 riffle cross-sections in Twin Lakes Creek.

STREAM NAME: Lost Creek

STREAM REACH: From the headwaters to the mouth - 19.9 miles.

LOCATION: Sec. 35, T6N, R12W to Sec. 32, T6N, R9W

DESCRIPTION OF STREAM REACH:

The origin of Lost Creek is in the southeastern corner of the Flint Creek Range. Lost Creek flows southeasterly for most of its length, then bends in a northeasterly direction for the remainder. The creek flows into the Clark Fork about 1¼ miles south of Galen. The stream flows through generally rolling open country in its upper sections. Lower down, the creek enters the Deer Lodge valley where it passes through extensive hay and pasture lands. The headwater area is characterized by good riparian cover and a substrate of boulder and cobble. Riparian habitats are badly damaged in much of the lower portion, where silt and gravel are the primary substrate materials.

Lost Creek has a length of approximately 20 miles and drains an area of 61 square miles. Irrigation diversion systems in the southern Deer Lodge valley are so complex that natural streamflow patterns are extremely altered. Irrigation withdrawals can be excessive, and dewatering is common in some reaches.

Additional reductions in fishery potential do not appear likely at this time. The major obstacles to better fish production are dewatering and destruction of riparian vegetation by livestock.

GAME FISH SPECIES PRESENT: Brown trout, cutthroat trout, bull trout, brook trout, mountain whitefish

FISHERY:

A section just upstream from the mouth of the Clark Fork was sampled. Despite some unfavorable land use practices this section is one of the better habitats remaining in the lower portion of the stream. Two sampling periods were employed to determine whether brown trout from the Clark Fork were entering Lost Creek to spawn. The first sample in August, 1983, showed the fish fauna to be composed of coarsescale suckers, longnose suckers, redside shiners, juvenile whitefish and brown trout. Brown trout were the most abundant fish species, and their population was estimated to be 808 per mile. Average brown trout length was 9.0 inches, and the largest was 14.7 inches. A second population estimate was made in late October, 1983, when spawners from the Clark Fork were ascending the tributaries. This population estimate was 2,680 fish per mile. Due to difficulties in recapturing a sufficient number of marked fish, this was probably overestimated. It does appear that the population was high during the second sampling period, probably considerably higher than the August estimate. These fish were presumably migrants from the Clark Fork.

Additional support for the presence of a spawning run of brown trout from the Clark Fork is offered by a comparison of average lengths between the two sampling periods. The October sample of brown trout averaged 10.8 inches in length, 1.8 inches greater than the August sample average. The greatest fish length recorded in October was 19.6 inches, 4.9 inches longer than the largest fish taken in August. It seems certain that the increased average and maximum lengths recorded in the late sample reflect a change in population composition due to the entry of Clark Fork browns into the stream.

Mountain whitefish were represented only by juveniles in the August sample, while large numbers of adults in spawning condition were present in the October sample. These adults must have ascended Lost Creek from the Clark Fork. It thus appears that despite unfavorable land use practices, Lost Creek provides not only a substantial fishery for resident trout, but provides spawning habitat for Clark Fork fish and, therefore, makes a contribution to that fishery as well.

WILDLIFE:

Lost Creek provides substantial waterfowl habitat. Overflows and beaver ponds in the lower stream offer good opportunities for waterfowl production as well as migrant resting and feeding sites.

Headwater areas are used by elk, moose, mule deer and bighorn sheep. White-tailed deer are common where sufficient willow areas remain. Ruffed, Franklin's and blue grouse are associated with upstream riparian habitat, and grey partridge are common in the lower areas. Beaver, mink and muskrats are common furbearers. A few red foxes are associated with downstream riparian habitat.

WETTED PERIMETER:

Cross-sectional measurements were made in a 41-foot section of Lost Creek located near its confluence with the Clark Fork River (SW, NE, Sec. 6, T5N, R9W). Three riffle cross-sections were established in this section. The WETP program was calibrated to field data collected at flows of 12.0, 62.8, 67.0 and 83.5 cfs.

The relationship between wetted perimeter and flow from a composite of the three riffle cross-sections is shown in Figure 16. Lower and upper inflection points occur at approximate flows of 8 and 16 cfs, respectively.

WHY FLOW IS NECESSARY:

The requested flow is necessary to maintain the substantial resident trout fishery as well as to provide adequate passage, spawning and rearing habitat for migrant brown trout and whitefish which enter from the Clark Fork River; to provide dilution water for the Clark Fork River; and to assist in maintenance of habitat for those wildlife species which depend upon the stream and its riparian zone for their food, water and shelter.

FLOW REQUEST:

January 1 - December 31--16 cfs (11,583 A.F./yr.)

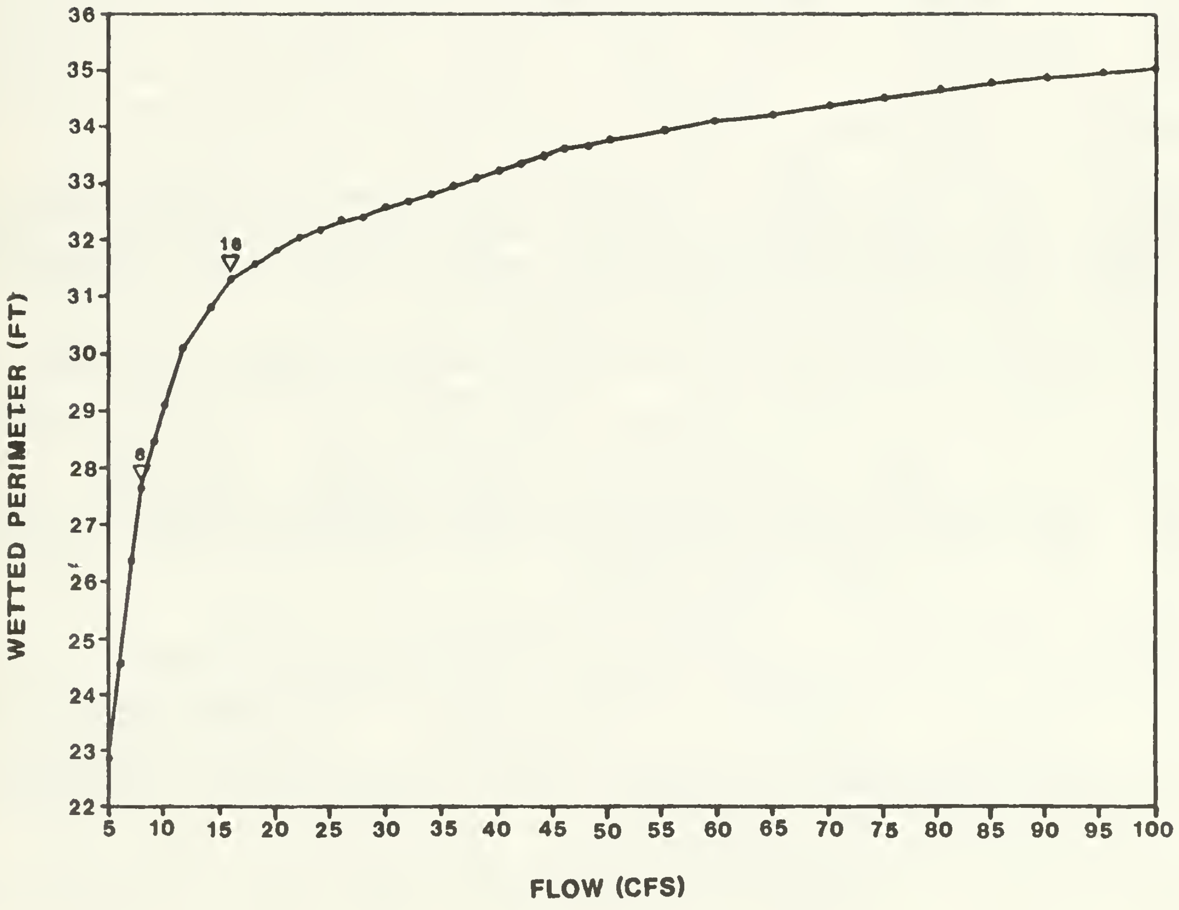

Figure 16. The relationship between wetted perimeter and flow from a composite of 3 riffle cross-sections in Lost Creek.

STREAM NAME: Racetrack Creek

DESCRIPTION OF THE BASIN:

Racetrack Creek begins in the south central Flint Creek Range and flows generally eastward to its confluence with the Clark Fork 1¼ miles northeast of Racetrack. The stream has a drainage area of 58 square miles. Tributaries to Racetrack Creek are Granite, North Fork Racetrack and Thornton creeks. Lakes in the drainage are Thornton, Hunter's, Porcupine, Big and Little Pozega, Meadow, Fisher, Racetrack, Little Racetrack, Mud, Dead, Albicaulis, Alpine and Bowman lakes. Many of the lakes have raised outlets to store irrigation water.

The upper reaches of Racetrack Creek flow through timbered, mountainous terrain. Surrounding slopes are steep, although stream gradient is modest. Bank vegetation is well established and pool formation is good. Substrate is boulder, cobble, gravel and some granitic sand. Fish habitat is generally excellent. Water transparency is high and the general aspect of the reach is visually attractive. Land use is mostly for recreation, logging and water production.

At about its midpoint, the creek emerges into morainal deposits, flows into the valley proper and joins the Clark Fork. Substrates change from boulder and rubble in the upper reaches to cobble, gravel and silt near the mouth.

The channel morphology is quite different between the upper and lower reaches of the stream. In the upper reach (#1) the stream has historically had no water depletions for irrigation. The channel is larger and carries a larger flow. Conversely, the lower reach (#2) has been depleted for irrigation for many years and some natural water loss into the gravel alluvium occurs. Thus, the channel is much smaller than in Reach #1 and requires less flow for fishery maintenance.

Riparian vegetation is well established in the headwaters, nearly eliminated in the middle reaches, and moderately well preserved near the mouth. Land use in the drainage includes logging, hay and livestock production and recreation. Irrigation diversions and interconnections are complex in the drainage, and dewatering is severe in the lower stream.

STREAM NAME: Racetrack Creek

STREAM REACH: #1. From the confluence of the North Fork Racetrack Creek to the Deerlodge National Forest boundary - 9.3 miles.

LOCATION: Sec. 2, T6N, R12W to Sec. 13, T6N, R11W

GAME FISH SPECIES PRESENT: Brown trout, cutthroat trout, brook trout, mountain whitefish

FISHERY:

Reach #1 of Racetrack Creek supports good populations of brown, brook and cutthroat trout. Brown trout are confined to the lower sections of the reach as are mountain whitefish. Brook trout distribution extends further upstream than that of brown trout. Cutthroat trout are distributed from the headwaters to the downstream end of the reach. Sculpins occur throughout the reach.

Due to the relatively low nutrient level, fish sizes are modest (12-inch specimens are large for this habitat). Numbers of fish are substantial, however. Fishing is extensive due to good access and the presence of a U.S. Forest Service (USFS) campground in the lower portion. Much of the recreational use of the campground is centered on angling. The value of the fishery is, therefore, greater than might be anticipated from stream size and fish population characteristics.

WILDLIFE:

This section is inhabited by lynx, mink, beaver, muskrat and marten. Game birds include all mountain grouse species. Big game species present are moose, elk and mule deer.

Use of this section by waterfowl is small. A few beaver ponds provide some nesting opportunity for ducks.

WETTED PERIMETER:

Cross-sectional measurements were made in a section of Reach #1 located near the Deerlodge National Forest boundary (NE, NE, Sec. 13, T6N, R11W). Three riffle cross-sections were established in this section. The WETP program was calibrated to field data collected at flows of 36.5, 95.2 and 217.2 cfs.

The relationship between wetted perimeter and flow from a composite of the three riffle cross-sections is shown in Figure 17. Lower and upper inflection points occur at approximate flows of 13 and 26 cfs, respectively.

WHY FLOW IS NECESSARY:

The requested flow is necessary to maintain existing resident trout populations on this popular fishing stream; to provide good quality water to lower Race Track Creek and, in turn, to the Clark Fork River to help dilute toxic pollutants in that stream; and to assist in maintenance of habitat for those wildlife species which depend upon the stream and its riparian zone for food, water and shelter.

FLOW REQUEST:

January 1 - December 31--26 cfs (18,823 A.F./yr.)

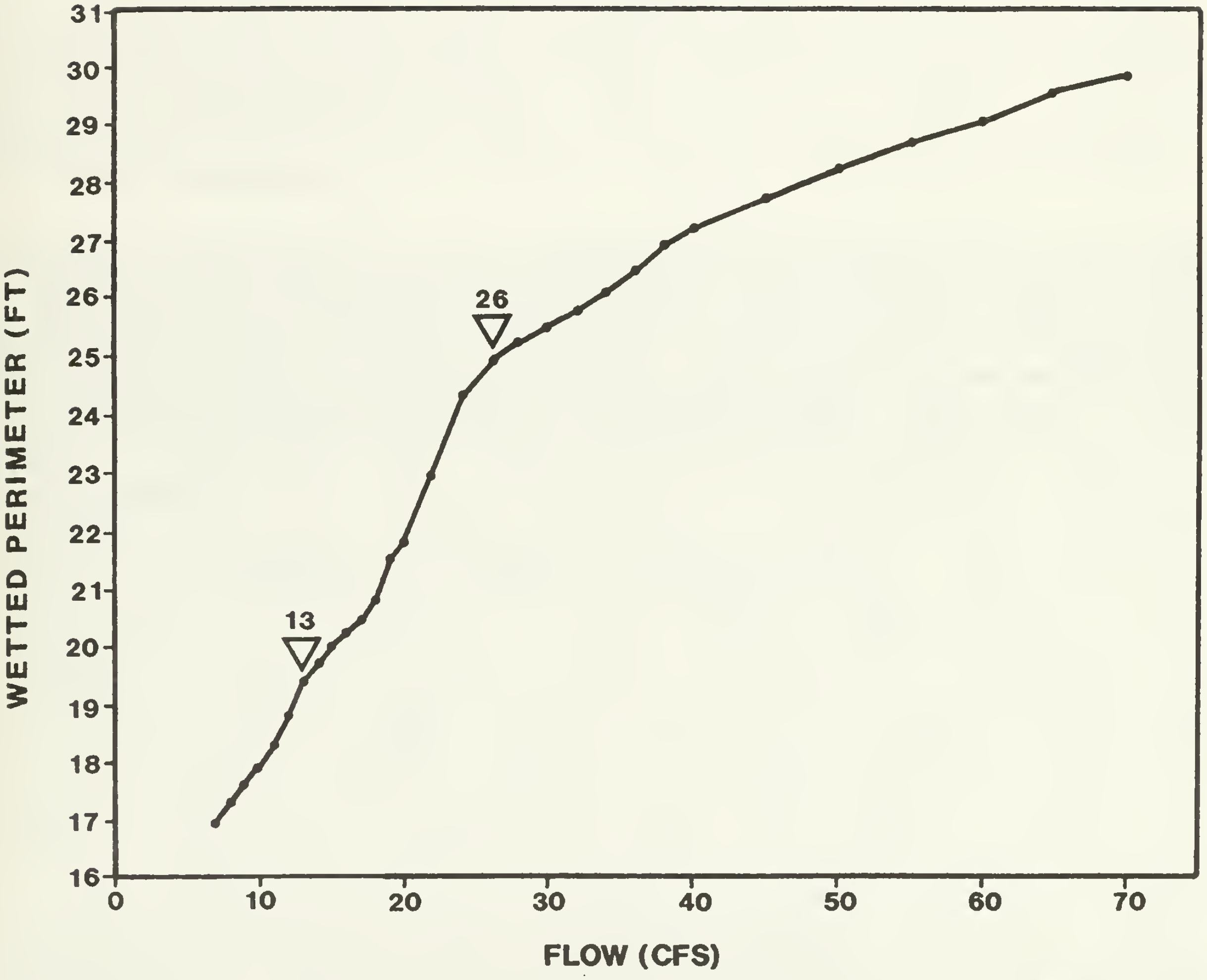

Figure 17. The relationship between wetted perimeter and flow from a composite of 3 riffle cross-sections in Racetrack Creek near the Deerlodge National Forest boundary.

STREAM NAME: Racetrack Creek

STREAM REACH: #2. From the Deerlodge National Forest boundary to the mouth - 10.8 miles.

LOCATION: Sec. 13, T6N, R11W to Sec. 9, T6N, R9W

GAME FISH SPECIES PRESENT: Brown trout, cutthroat trout, brook trout, mountain whitefish

FISHERY:

A section was sampled by electrofishing just upstream from the mouth. The section has cobble, gravel and silt substrate and averages 15 to 20 feet in width. Riparian vegetation is in reasonably good condition, and is mainly composed of willow and alder. Gradient is low and pool and riffle habitats are well defined. Bordering lands are used for livestock pasture. Streamflows are better in this section than in upstream sections which are severely dewatered.

This section supports an excellent trout population. Upstream fish populations are probably much lower because of extremely low flows due to agricultural dewatering. Sampling in this section took place in August and October, 1983, in an attempt to determine possible spawning use by brown trout from the Clark Fork. The August sample recorded sculpins, numerous brown trout and a few cutthroat and brook trout. The population of brown trout was estimated to be 565 fish per mile. The October sample revealed the presence of numerous spawning whitefish from the Clark Fork and the brown trout population was estimated to be 576 fish per mile. Since estimated numbers of brown trout did not differ significantly between August and September, the average size of brown trout greater than 6.0 inches in the two samples was compared - 9.0 inches in August and 10.6 inches in October. The average length of fish in the two samples was significantly different at the 95% confidence level. This suggests that Clark Fork brown trout did enter the stream to spawn. Since the river fish are of larger average size than those in Racetrack Creek, the influx of Clark Fork fish would account for the increased average size observed in October. Maximum brown trout size in the two samples increased from 15.9 inches in August to 17.2 inches in October, again suggesting Clark Fork River browns enter Racetrack Creek. It thus appears that the stream is providing a spawning site for both brown trout and mountain whitefish from the main river and thereby contributing to that fishery.

WILDLIFE:

Both migrant and local waterfowl use the middle reaches of Racetrack Creek. However, use is moderate due to the small size of the stream.

Mink, beaver and muskrats are the principal furbearers along Racetrack Creek. Game bird species include blue, Franklin's and ruffed grouse, as well as hungarian partridge. Big game animals are elk, moose and mule deer upstream, with white-tailed deer common in the few areas where adequate riparian cover remains.

WETTED PERIMETER:

Cross-sectional measurements were made in a 13-foot section of Reach #2 located near the confluence with the Clark Fork River (SE, SE, Sec. 8, T6N, R9W). Three riffle cross-sections were established in this section. The WETP program was calibrated to field data collected at flows of 0.8, 6.5 and 13.0 cfs.

The relationship between wetted perimeter and flow from a composite of the three riffle cross-sections is shown in Figure 18. Lower and upper inflection points occur at approximate flows of 1 and 3 cfs, respectively.

WHY FLOW IS NECESSARY:

The requested flow is necessary to maintain the excellent resident trout population in the reach and to allow brown trout and whitefish to enter from the Clark Fork River to spawn in the fall; to provide good quality water to the Clark Fork River for dilution of toxic mining wastes; and to assist in the maintenance of habitat for those wildlife species present which depend upon the stream and its riparian zone for food, water and shelter.

FLOW REQUEST:

January 1 - December 31--3 cfs (2,172 A.F./yr.)

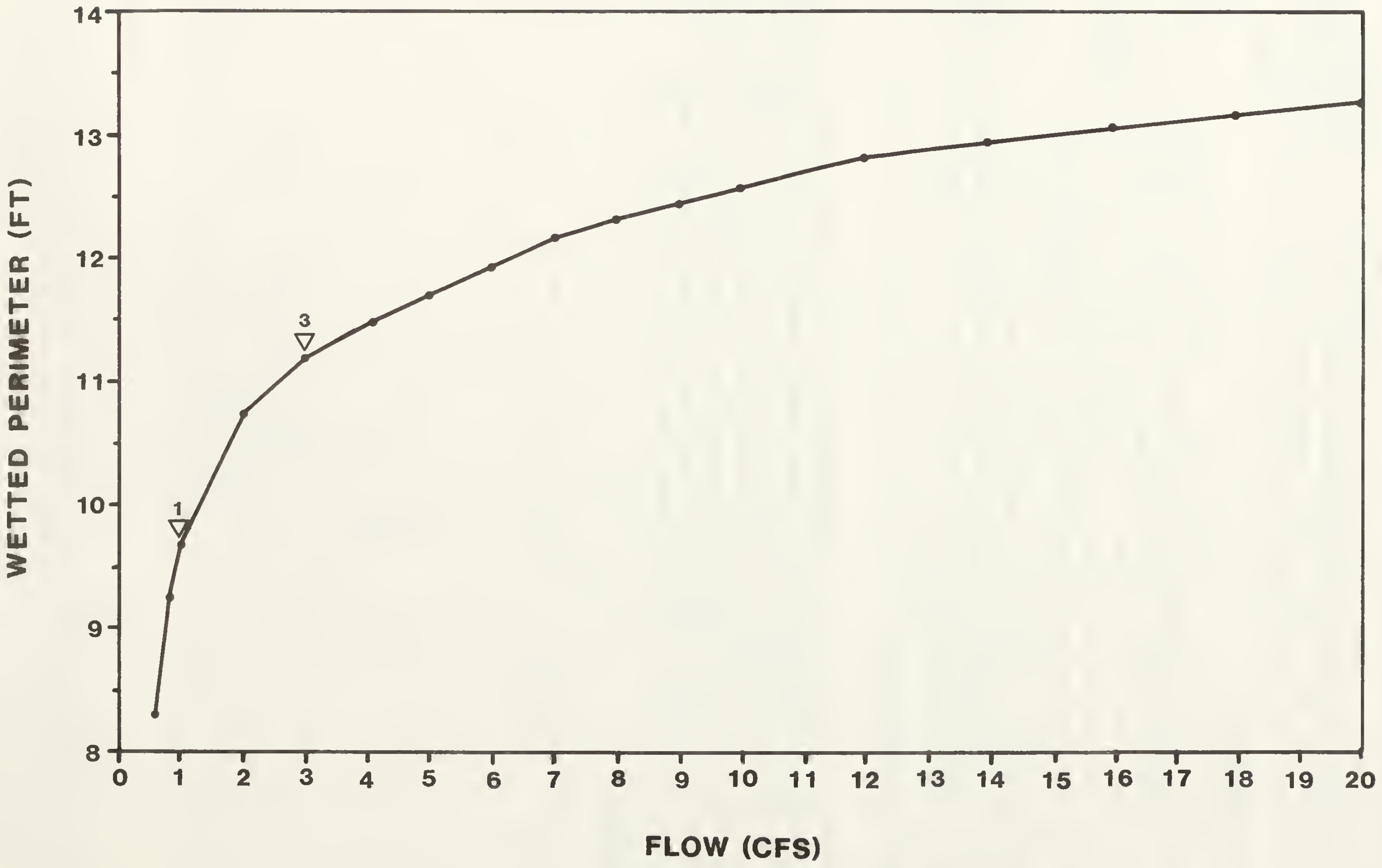

Figure 18. The relationship between wetted perimeter and flow from a composite of 3 riffle cross-sections in Racetrack Creek near its mouth.

STREAM NAME: Dempsey Creek

STREAM REACH: From Caruthers Lake to the mouth - 17.1 miles.

LOCATION: Sec. 29, T7N, R11W to Sec. 33, T7N, R9W

DESCRIPTION OF STREAM REACH:

Dempsey Creek arises on the east side of the Flint Creek Range and flows easterly to join the Clark Fork River 5½ highway miles south of Deer Lodge. The upper reaches are in mountainous, forested terrain. The lower reaches traverse large gravel morains covered with herbaceous vegetation. Riparian vegetation in the lower portions of the stream consists of alder, willow and cottonwood. Substrate is boulder and cobble in the upper reaches gradually changing to gravel and silt near the mouth. Lakes in the basin include Bohn, Ryan, Goat, Little Goat, Caruthers and Mountain Ben. Dempsey Creek drains an area of about 34 square miles.

The area's land use is for timber, agriculture and recreation. Extensive water storage on many of the basin's lakes has been achieved by damming the outlets. Stream dewatering is severe. Dempsey Creek flows into a diversion from the Clark Fork as it nears the river. The diversion and pumping sump constructed near the mouth probably have a negative effect on upstream migrants from the Clark Fork.

GAME FISH SPECIES PRESENT: Brown trout, cutthroat trout, brook trout

FISHERY:

Dempsey Creek was sampled near the Clark Fork about 4½ miles south of Deer Lodge. This stream section flows through pasture and has a good riparian zone. Banks are lined by willow and alder. Substrate is gravel and silt. Pool development is good, and some submerged aquatic vegetation is present. A considerable volume of groundwater appears to enter the stream in this area, which may ameliorate the effects of dewatering upstream. The stream is generally less than 10 feet in width.

Electrofishing found brown, brook and cutthroat trout to be present. Cutthroats were rare, brooks common, and browns abundant. The population estimate of all species combined was 776 fish per mile. In an attempt to determine whether brown trout from the Clark Fork might ascend Dempsey Creek to spawn, a second estimate was made in the October, 1983 spawning period. Estimated density of all species was 840 fish per mile. These estimates (776 and 840 fish per mile) were different at the 95% level of confidence. Although the number of fish increased, it is not likely that this reflects a major influx of Clark Fork brown trout. The population estimates are quite high for a stream of such diminutive size and they include a large number of small brown trout which may find their way into the Clark Fork. Dempsey Creek is an extremely productive fishery where the habitat has not been too badly damaged.

WILDLIFE:

Dempsey Creek supports ruffed, blue and Franklin's grouse, as well as hungarian partridge. Mule deer, moose and elk utilize the upper reaches. White-tailed deer are common in those areas where sufficient riparian habitat remains available. Mink, beaver and muskrats are the local furbearers associated with the stream.

The small size of Dempsey Creek reduces its value to waterfowl.

WETTED PERIMETER:

Cross-sectional measurements were made in a 65-foot section of Dempsey Creek located near its confluence with the Clark Fork River (NW, SW, Sec. 33, T7N, R9W). Two riffle cross-sections were established in this section. The WETP program was calibrated to field data collected at flows of 6.0, 11.0 and 12.1 cfs.

The relationship between wetted perimeter and flow from a composite of the two riffle cross-sections is shown in Figure 19. Lower and upper inflection points occur at approximate flows of 2.5 and 3.5 cfs, respectively.

WHY FLOW IS NECESSARY:

The requested flow is necessary to maintain the existing resident trout populations, some of which may migrate downstream into the Clark Fork and contribute to that fishery; to provide good quality water to the Clark Fork River for dilution of toxic pollutants from mining wastes; and to assist in maintenance of habitat for those wildlife species which depend upon the stream and its riparian zone for food, water and shelter.

FLOW REQUEST:

January 1 - December 31--3.5 cfs (2,534 A.F./yr.)

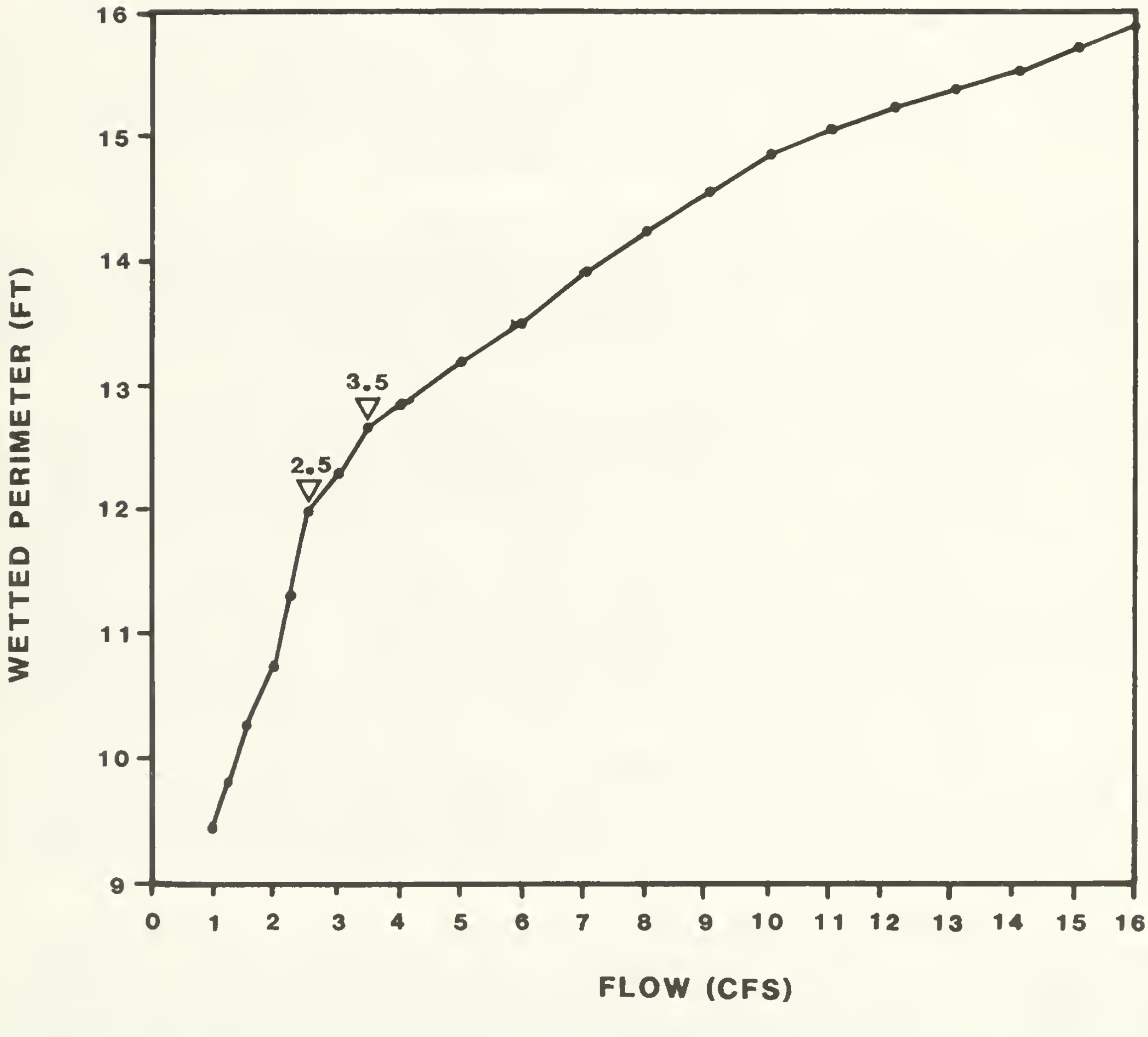

Figure 19. The relationship between wetted perimeter and flow from a composite of 2 riffle cross-sections in Dempsey Creek.

STREAM NAME: Little Blackfoot River

DESCRIPTION OF THE BASIN:

The Little Blackfoot originates along the Continental Divide and flows generally north before turning west for the majority of its length. It enters the Clark Fork one mile southeast of Garrison. It is a major Clark Fork tributary with a drainage area of 407 square miles. Tributaries to the Little Blackfoot are Spotted Dog, Trout, Hurd, Telegraph, Dog, North Trout and Snowshoe creeks.

The Little Blackfoot flows through mountainous terrain in its headwaters along the Continental Divide. This area is steep and timbered. Near Elliston it receives the waters of Dog Creek, turns west and traverses a gradually increasing valley section where it is paralleled by US Highway 12. The communities of Elliston and Avon are located in this reach. Major groundwater inflows appear to occur in the Avon area.

Substrate in the stream consists largely of boulders and rubble in the headwaters, changing to rubble and gravel in the lower reaches. Riparian vegetation in the mountainous area is alder, willow and spruce. The downstream reaches are dominated by willow and cottonwood.

Land use in the Little Blackfoot includes most of the types found west of the Divide. Timber cutting in the headwaters has been rather extensive. Past mining activity has been widespread, with severe consequences in water quality degradation continuing to the present. Minimal mining activity is taking place at present, however, acidic drainage from old mines is still a problem. Agriculture is the most widespread activity. Hay production and cattle grazing comprise the bulk of the use. Transportation corridors along the Little Blackfoot include a major U.S. highway and a railroad right-of-way. Both have severely occluded the narrow valley. Recreational use of the drainage is substantial in both winter and summer. Skiing, snowmobiling, hiking, fishing and hunting are some of the year-around activities. Fishing use is quite high due to easy access from Highway 12 and the stream's proximity to Helena.

In addition to the upstream problems there are a number of problems which occur downstream. Perhaps the most significant impacts on the Little Blackfoot are those from highway and railroad construction. Channel straightening has occurred in many sections, with concomitant decreases in fish habitat and increases in erosion due to the steepened gradient.

The reduction in stream channel length from railroad and highway construction and private channel alterations, and the resultant expansion of erosive capacity have created major ancillary difficulties for agricultural interests along the stream. Irrigation water withdrawals are significant in some sections.

STREAM NAME: Little Blackfoot River

STREAM REACH: #1. From Blackfoot Meadows to the confluence of Dog Creek - 17.4 miles.

LOCATION: Sec. 2, T7N, R7W to Sec. 6, T9N, R6W

GAME FISH SPECIES PRESENT: Brown trout, rainbow trout, westslope cutthroat trout, bull trout, brook trout, brook/bull trout hybrids, mountain whitefish

FISHERY:

The section sampled is located just west of the YMCA camp about 2½ miles south of Highway 12. This section has a boulder and rubble substrate with occasional areas of gravel. Riparian vegetation is moderate and consists of a willow-alder mixture. Stream width at low flow is about 15 feet. Pool development is fair to good.

Fishes collected here included brook, bull, brown and westslope cutthroat trout. Mottled sculpins were common, and a few hybrids between bull and brook trout were noted. Young of the year fishes included large numbers of brown trout, fewer brook trout, and a small number of cutthroat. Estimated population of all trout species was 645 fish per mile. This is an exceptionally dense population for so small a stream, and illustrates the productive nature of the drainage.

WILDLIFE:

This portion of the Little Blackfoot drainage is used by elk, moose and mule deer. A few white-tailed deer utilize the section below the YMCA camp. Blue, ruffed and Franklin's grouse, beaver, mink and muskrat are associated with the riparian zone.

Much of the upper portion of the stream, of which this section is representative, is too small and precipitous to encourage waterfowl use. Beaver ponds are rather common, however, and these areas are important habitat for migrants and breeders.

WETTED PERIMETER:

Cross-sectional measurements were made in an 88-foot section of Reach #1 located at the YMCA camp approximately 2.0 miles upstream from the confluence of Dog Creek (NW, NE, Sec. 19, T9N, R6W). Three riffle cross-sections were established in this section. The WETP program was calibrated to field data collected at flows of 16.1, 17.1 and 90.6 cfs.

The relationship between wetted perimeter and flow from a composite of the three riffle cross-sections is shown in Figure

20. Lower and upper inflection points occur at approximate flows of 5 and 17 cfs, respectively.

WHY FLOW IS NECESSARY:

The requested flow is necessary to maintain the existing resident trout populations; to provide water to the lower reaches of the stream where dewatering is sometimes severe; to provide good quality water to the lower reach and, in turn, to the Clark Fork River to dilute toxic pollutants from mining wastes; and to assist in maintenance of habitat for those wildlife species which depend upon the stream and its riparian zone for food, water and shelter.

FLOW REQUEST:

January 1 - December 31--17 cfs (12,307 A.F./yr.)

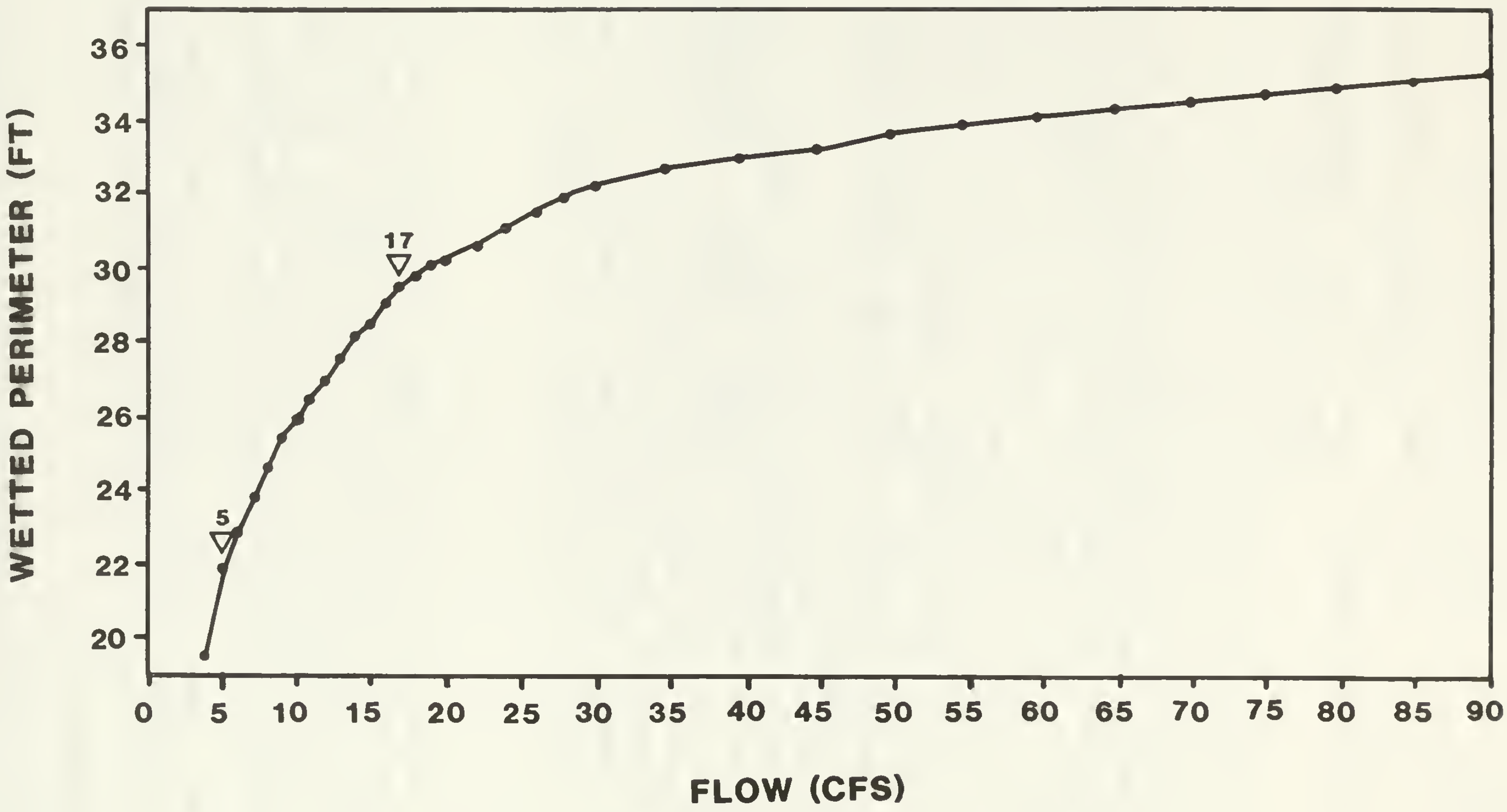

Figure 20. The relationship between wetted perimeter and flow from a composite of 3 riffle cross-sections in the Little Blackfoot River above the confluence of Dog Creek.

STREAM NAME: Little Blackfoot River

STREAM REACH: #2. From the confluence of Dog Creek to the mouth - 26.9 miles.

LOCATION: Sec. 6, T9N, R6W to Sec. 24, T9N, R10W

GAME FISH SPECIES PRESENT: Brown trout, rainbow trout, cutthroat trout, bull trout, brook trout, mountain whitefish

FISHERY:

The section sampled is located seven highway miles above Garrison and is characterized by less disturbance than other areas of the Little Blackfoot. The bank vegetation is fairly well established and includes willow, dogwood, chokecherry and cottonwood. A short stretch of this section consists of old highway riprap, and a longer section is bordered by railroad embankment riprap. Substrate is cobble and gravel and appears to be unstable, a condition typical of the Little Blackfoot in its current state. Pool development is fair, much less than might be expected. Dewatering is substantial in dry years when heavy irrigation withdrawals are made.

Sampling in this stretch revealed the presence of the mottled sculpin, as well as the shorthead sculpin. Common suckers and large numbers of mountain whitefish were also present. Trout species observed were westslope cutthroat and brown trout. The cutthroat comprised less than one percent of the trout taken. Brown trout numbers were estimated to be 906 fish per mile. This is a high population considering the degraded nature of the stream.

WILDLIFE:

Furbearers along the lower reach include mink, muskrat and beaver. Blue and ruffed grouse are found in the riparian zone. Mule deer are seasonal users of the stream course. White-tailed deer are distributed along the lower river and may reach high densities where adequate riparian cover remains. Black bears commonly forage in the riparian zone when chokecherries are ripe.

Use of the lower Little Blackfoot by waterfowl is largely confined to oxbows. Late migrants and early nesters may utilize the main stream when the more placid waters are frozen.

WETTED PERIMETER:

Cross-sectional measurements were made in a 225-foot section of Reach #2 located near the confluence with the Clark Fork River (SE, Sec. 24, T9N, R10W). Three riffle cross-sections were established in this section. The WETP program was calibrated to field data collected at flows of 111.6, 402.0, 435.0 and 845.0 cfs.

The relationship between wetted perimeter and flow from a composite of the three riffle cross-sections is shown in Figure 21. Lower and upper inflection points occur at approximate flows of 45 and 110 cfs, respectively.

WHY FLOW IS NECESSARY:

The requested flow is necessary to maintain the existing resident trout populations and to help prevent further detrimental dewatering in some stream sections; to provide high quality water to the Clark Fork River for dilution of toxic pollutants from mining wastes; and to help protect the habitat of those wildlife species which depend upon the stream and its riparian zone for food, water and shelter.

FLOW REQUEST:

January 1 - December 31--85 cfs (61,537 A.F./yr.)

NOTE: A flow less than that indicated by the upper inflection point (110 cfs) was chosen because a significant amount of habitat of the Little Blackfoot has been altered by man through channel alterations and excessive dewatering. These alterations have severely impacted the fishery in this reach.

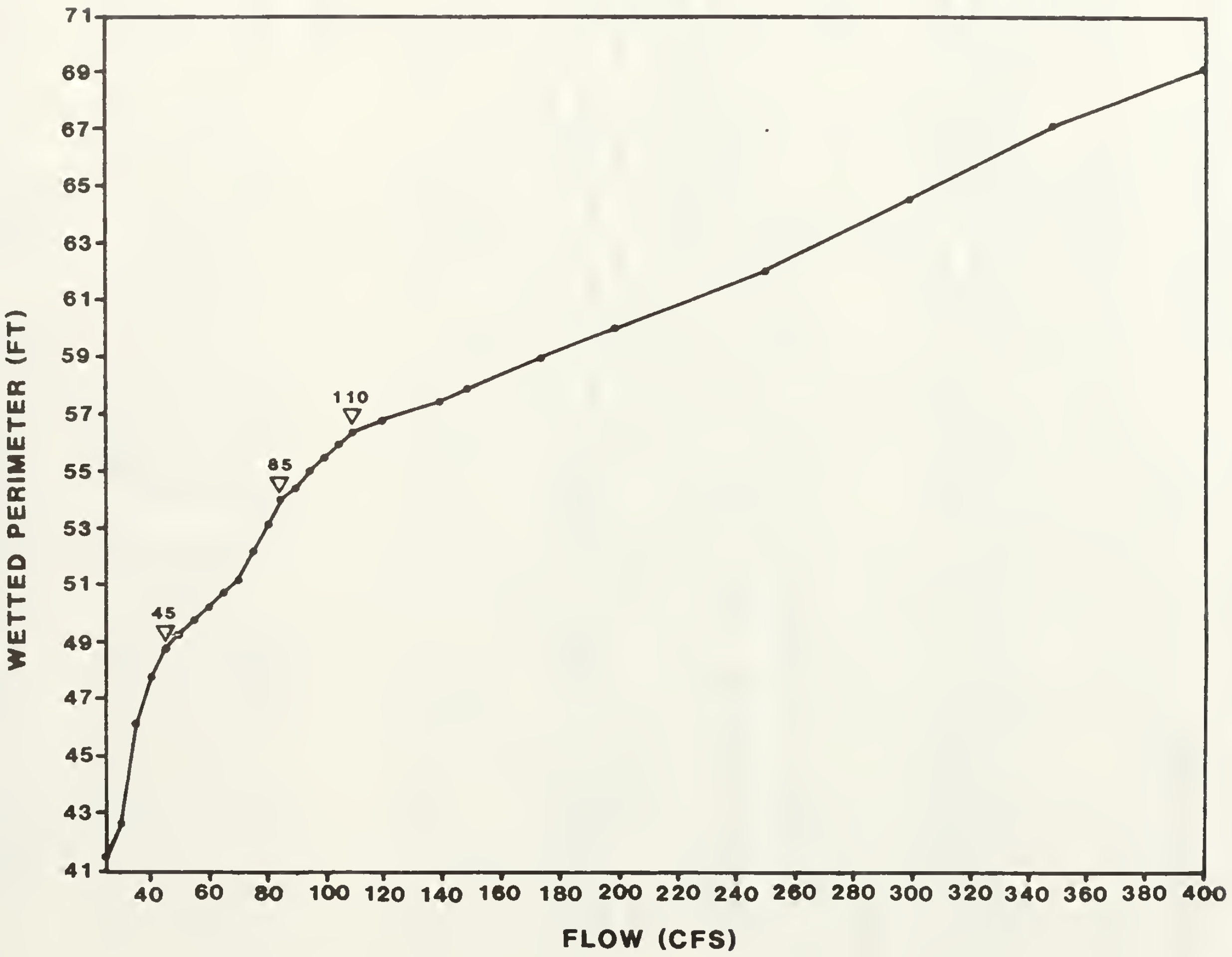

Figure 21. The relationship between wetted perimeter and flow from a composite of 3 riffle cross-sections in the Little Blackfoot River near its mouth.

STREAM NAME: Snowshoe Creek

STREAM REACH: From the confluence of Deadwood Gulch to the mouth - 9.2 miles.

LOCATION: Sec. 22, T11N, R7W to Sec. 26, T10N, R8W

DESCRIPTION OF STREAM REACH:

Snowshoe Creek is a small stream originating along the Continental Divide and flowing southeasterly to its confluence with the Little Blackfoot two miles east of Avon. The upper portion traverses a rolling, rather open region. The stream flows into a broad valley toward the mouth. Gradient in the lower portion is quite gentle, and the stream becomes very sinuous in this area. Much of the flow volume in the lower stream appears to be contribution from groundwater. In the upper stream, the substrate is formed of boulders, rubble and gravel. The substrate type changes downstream until, near the mouth, the predominant materials are gravel and silt. Land use in the drainage includes some timber harvest, livestock grazing, hay production, and recreation.

GAME FISH SPECIES PRESENT: Brown trout, cutthroat trout,
mountain whitefish

FISHERY:

The area of Snowshoe Creek sampled was immediately upstream from the mouth. This area is used for hay meadows and livestock grazing. The streambanks are badly eroded due to removal of woody riparian vegetation. The substrate is a mixture of gravel and silt, the latter apparently the result of poor land management practices. The stream is 10 to 15 feet in width with a gentle gradient and fair pool development. Considerable submerged aquatic vegetation is present.

Electrofishing revealed the presence of coarsescale suckers, sculpins, mountain whitefish and brown trout. In upstream areas, cutthroat trout are common. Estimated number of brown trout per mile was 475 catchable size fish. Brown trout lengths reached 21 inches, and large numbers of small browns were present. Snowshoe Creek probably contributes significant numbers of fish to the Little Blackfoot population.

WILDLIFE:

The upstream reaches of Snowshoe Creek are used by elk and mule deer. Downstream areas produce a fair number of white-tailed deer despite the severely restricted extent of riparian vegetation. Furbearers using the stream are mink, muskrat and beaver. Riparian habitats are utilized by Franklin's, blue and ruffed grouse as well as hungarian partridge.

The stream receives a fair amount of waterfowl use, both migrant and breeding. The groundwater inflows extend the open water season and thus make the stream very desirable as waterfowl habitat.

WETTED PERIMETER:

Cross-sectional measurements were made in an approximate 110-foot section located near the confluence with the Little Blackfoot River (NE, NE, Sec. 26, T10N, R8W). Three riffle cross-sections were established in this section. The WETP program was calibrated to field data collected at flows of 10.8 and 18.2 cfs.

The relationship between wetted perimeter and flow from a composite of the three riffle cross-sections is shown in Figure 22. Lower and upper inflection points occur at approximate flows of 5 and 9 cfs, respectively.

WHY FLOW IS NECESSARY:

The requested flow is necessary to maintain a significant resident trout population and to help provide flows for the Little Blackfoot River fishery downstream; to provide good quality water to the Clark Fork River for dilution of mining wastes; and to help protect the habitat of those wildlife species which depend upon the stream and its associated riparian zone for food, water and shelter.

FLOW REQUEST:

January 1 - December 31--9 cfs (6,516 A.F./yr.)

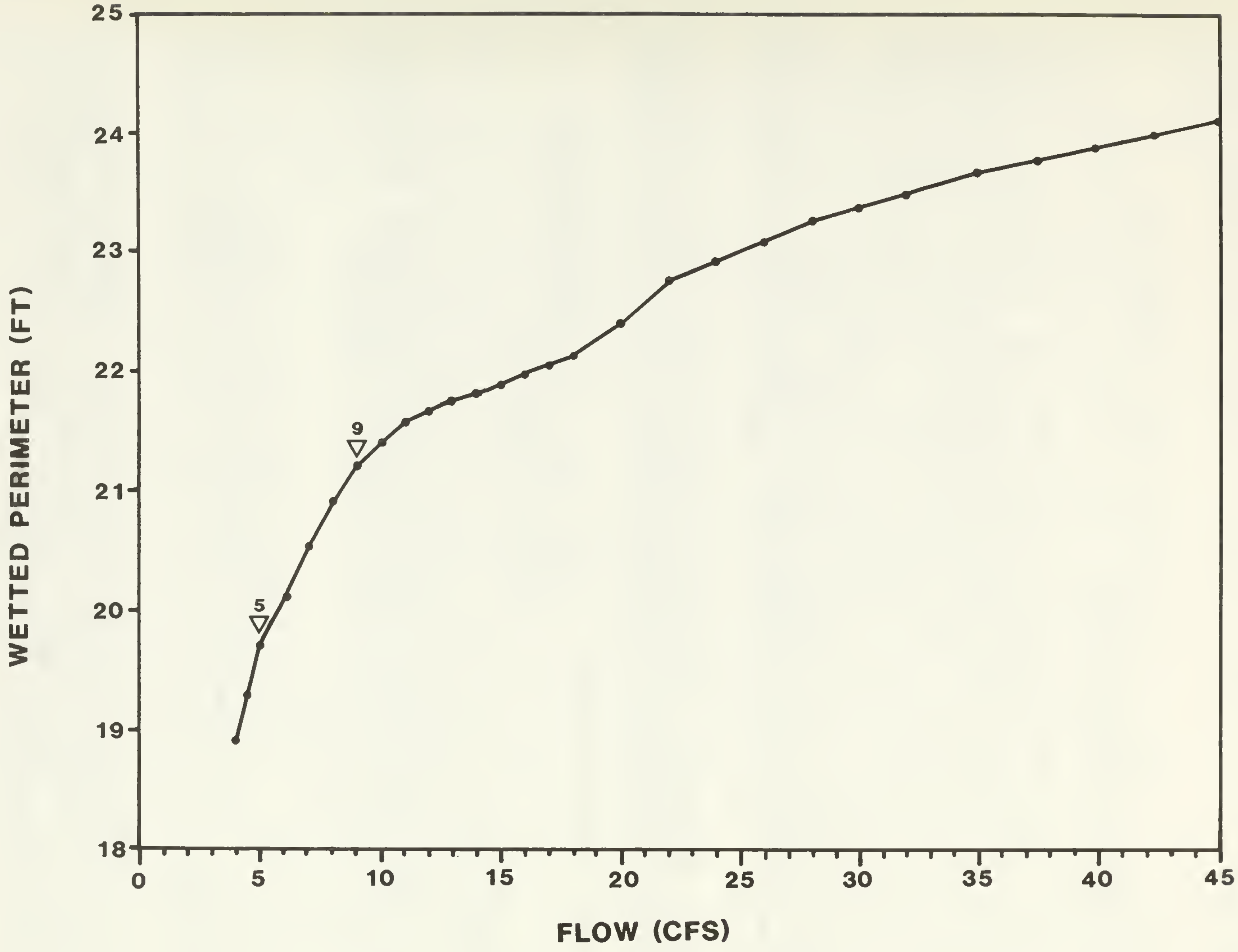

Figure 22. The relationship between wetted perimeter and flow from a composite of 3 riffle cross-sections in Snowshoe Creek.

STREAM NAME: Dog Creek

STREAM REACH: From the confluence of Dago Gulch to the mouth - 15.5 miles.

LOCATION: Sec. 16, T11N, R6W to Sec. 6, T9N, R6W

DESCRIPTION OF STREAM REACH:

Dog Creek is a small stream arising along the Continental Divide. It flows generally southward, then bends west a few miles before entering the Little Blackfoot about one mile east of Elliston. Tributaries to Dog Creek include MacDonald Creek, Uncle George Creek and Hope Creek. Upper stream reaches are in open, rolling terrain with occasional timbered sections. Extensive beaver pond and willow thickets are located in the upstream areas. Lower down, the stream has been channelized and fish habitat is poor.

No major threats to Dog Creek are currently known. As long as livestock grazing and timber harvest levels are moderate, no serious degradation is anticipated. Mining activity is currently very low.

Land use in the Dog Creek area is mostly timbering and livestock grazing. Recreation is a major activity due, in part, to the closeness of the stream to Helena.

GAME FISH SPECIES PRESENT: Brown trout, westslope cutthroat trout, bull trout, brook trout, mountain whitefish

FISHERY:

A section of Dog Creek from the mouth upstream was sampled in 1983. This area had a cobble and gravel substrate, reasonably good bank cover, and little aquatic vegetation. An area adjoining the section upstream had been channelized. The stream was about 10 feet wide.

Species taken in this section were brown, brook, bull and cutthroat trout, with browns comprising the vast majority of the population. The estimated population of 218 browns per mile was surprisingly low and may have been the result of upstream habitat destruction.

Another section located about midway in the stream reach, just below an extensive beaver pond complex, was also sampled. Substrate is gravel and silt. Alder and willow bank cover is of good quality. Stream width is about eight feet. Gradient is moderate with good pool development.

Brown trout outnumbered cutthroat by about 3 to 1. The estimated number of all trout species was 541 fish per mile. This is an impressively abundant population for a stream of such small size.

Cutthroat from this stream were examined in 1981, and determined to be the pure westslope strain (Behnke 1981, personal communication).

WILDLIFE:

Elk, moose and mule deer are the principal big game species using the Dog Creek area. Beaver, mink and muskrat are the principal furbearers. Game birds include blue, ruffed and Franklin's grouse.

Some waterfowl use occurs in the meadow and beaver pond sections of Dog Creek. Nesting waterfowl of several species utilize the beaver ponds for brood rearing.

WETTED PERIMETER:

Cross-sectional measurements were made in a 17-foot section located near the confluence with the Little Blackfoot River (SW, SW, Sec. 6, T9N, R6W). Two riffle cross-sections were established in this section. The WETP program was calibrated to field data collected at flows of 11.5 and 114.3 cfs.

The relationship between wetted perimeter and flow from a composite of the two riffle cross-sections is shown in Figure 23. Lower and upper inflection points occur at approximate flows of 6 and 12 cfs, respectively.

WHY FLOW IS NECESSARY:

The requested flow is necessary to maintain the resident trout population and to help provide water for the Little Blackfoot River fishery downstream; to provide good quality water to the Clark Fork River for dilution of toxic mining wastes; and to help protect the habitat of those wildlife species which depend upon the stream and its associated riparian zone for food, water and shelter.

FLOW REQUEST:

January 1 - December 31--12 cfs (8,688 A.F./yr.)

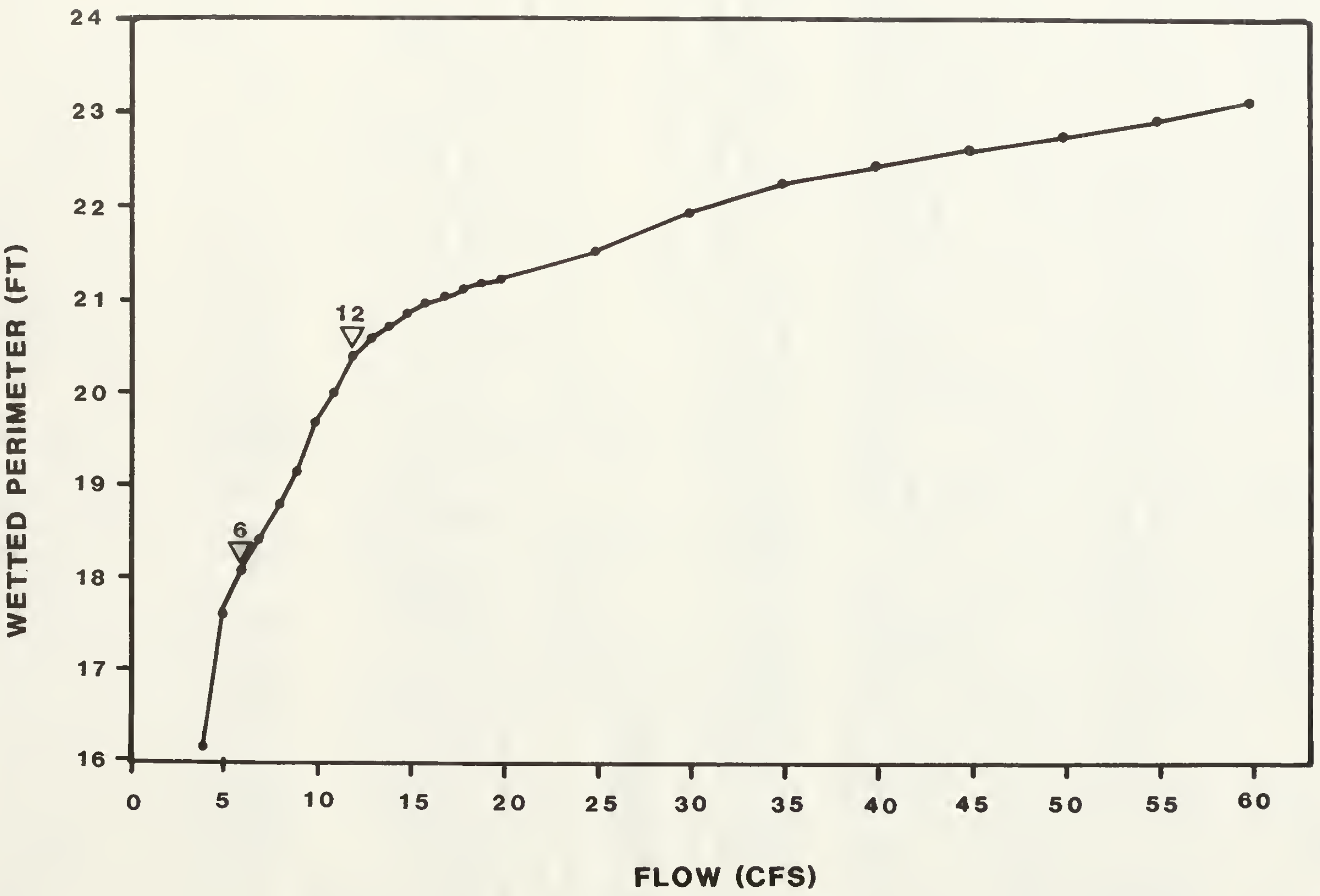

Figure 23. The relationship between wetted perimeter and flow from a composite of 2 riffle cross-sections in Dog Creek.

STREAM NAME: Gold Creek

STREAM REACH: From the headwaters to the mouth - 15.0 miles.

LOCATION: Sec. 16, T8N, R12W to Sec. 31, T10N, R10W

DESCRIPTION OF STREAM REACH:

Gold Creek drains from the northeastern Flint Creek Range and empties into the Clark Fork just east of the town of Gold Creek. It has a drainage area of about 66 square miles.

The upper creek flows through gentle mountainous terrain where intensive placer mining activity has severely damaged aquatic productivity. Timber harvesting, livestock grazing and recreation are the major land uses in the upstream reaches. The lower stream sections are dewatered by irrigation for hay production.

GAME FISH SPECIES PRESENT: Brown trout, cutthroat trout, brook trout, mountain whitefish

FISHERY:

Gold Creek was sampled in its lower reaches about 1/8 mile above its confluence with the Clark Fork. The section sampled was 300 feet in length and has been floored with planks which are now largely undermined. This section may have been straightened in the past. The substrate is rubble and gravel. Aquatic vegetation is primarily algae. The upstream limit of the section is at the base of an irrigation diversion dam which was formerly a complete barrier to upstream fish movement. Flood damage to the structure has altered the situation and upstream passage now appears to be possible.

Species caught included brook trout, cutthroat trout, brown trout and mountain whitefish. Cutthroats were uncommon in this downstream section, but are likely the dominant species in upstream areas. Specimens examined appeared to be the westslope strain.

A population estimate in early August, 1983 found 370 brown trout per mile with an average length of 10.1 inches. To determine whether game fish from the Clark Fork might be ascending Gold Creek to spawn, a second estimate in the same section was made in October, 1983. The number of brown trout was estimated to be 1,108 per mile with an average length of 13.7 inches. This number is significantly different from the August estimate at the 95% confidence level. Several hundred spawning whitefish were also taken in October, presumably migrants from the Clark Fork.

It is apparent that substantial numbers of brown trout and whitefish from the Clark Fork utilize Gold Creek as a spawning stream. Thus Gold Creek is especially valuable as a contributor of young fish to the Clark Fork because few tributaries in the area are of sufficient size, or have adequate water quality, to support trout and whitefish reproduction. The increase in spawning area made available to migrants by the alteration of the irrigation diversion dam will likely increase the importance of this tributary to the Clark Fork fishery.

WILDLIFE:

White-tailed deer, raccoons, beaver, mink and muskrats utilize Gold Creek and its margins in the lower reaches. It is probably used by elk and mule deer further upstream.

Gold Creek is not a major waterfowl habitat due to its small size. It likely receives some use from both local birds and migrants.

WETTED PERIMETER:

Cross-sectional measurements were made in a 20-foot section of Gold Creek located approximately 0.8 mile upstream from its confluence with the Clark Fork River (SE, Sec. 36, T10N, R11W). Three riffle cross-sections were established in this section. The WETP program was calibrated to field data collected at flows of 32.8, 37.0, 50.5 and 90.0 cfs.

The relationship between wetted perimeter and flow from a composite of the three riffle cross-sections is shown in Figure 24. Lower and upper inflection points occur at approximate flows of 20 and 34 cfs, respectively.

WHY FLOW IS NECESSARY:

The requested flow is necessary to maintain the existing resident trout populations and to provide spawning habitat for migrant brown trout and whitefish from the Clark Fork River; to provide good quality water to the Clark Fork River for dilution of toxic pollutants present in that stream's water; and to help protect the habitat of those wildlife species which depend upon the stream and its associated riparian zone for food, water and shelter.

FLOW REQUEST:

January 1 - December 31--34 cfs (24,615 A.F./yr.)

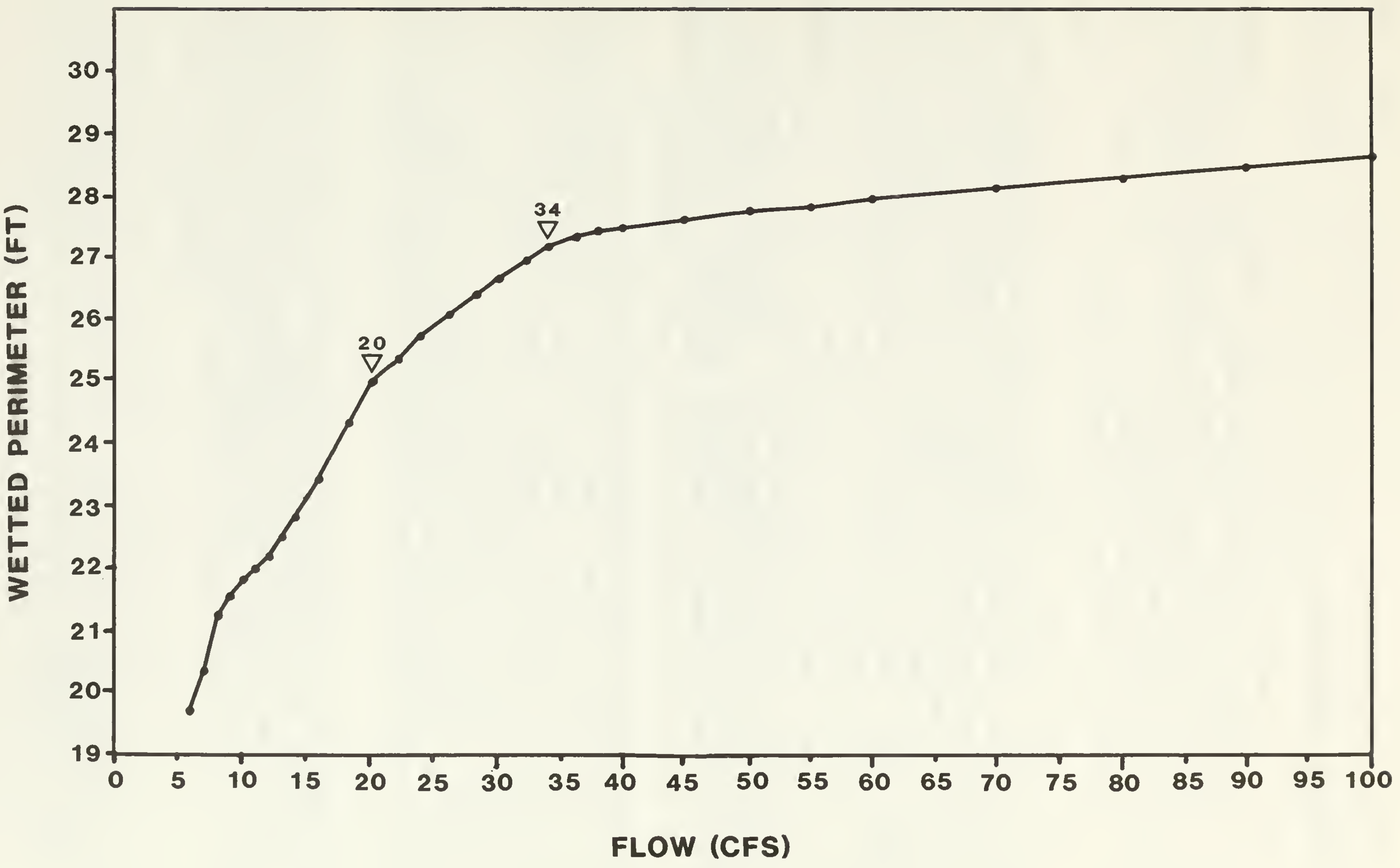

Figure 24. The relationship between wetted perimeter and flow from a composite of 3 riffle cross-sections in Gold Creek.

STREAM NAME: Flint Creek

DESCRIPTION OF THE BASIN:

Flint Creek is a major tributary of the Clark Fork. Its course begins at the dam on Georgetown Lake and it flows 38.8 miles in a northerly direction to its confluence with the Clark Fork near Drummond. Flint Creek drains 499 square miles of the Flint Creek and John Long Mountains. Tributaries to Flint Creek include Lower Willow, Henderson, Trout, Stuart Mill, North Fork of Flint, Fred Burr, Boulder, Douglas and Barnes creeks.

Upper Flint Creek flows through a canyon just downstream from Georgetown Lake. The creek then enters the Philipsburg valley, an area of extensive, open, rolling topography used primarily for livestock grazing and hay production. Irrigation diversions are significant in reducing flow volumes in both Flint Creek and its tributaries throughout the valley. The stream enters a constricted area as it exits the Philipsburg valley. The topography then flattens as the creek flows into the flats extending from Maxville to the stream's mouth at Drummond. Irrigation water loss becomes progressively more severe as the creek flows downstream. Below Hall, irrigation diversions may cause complete flow interruptions. Upstream substrates are typically boulder and rubble changing to rubble and gravel in the Philipsburg valley. Downstream from Maxville, the streambed is rubble and gravel and contains silt in large quantities.

Riparian vegetation from the head of the Philipsburg valley to the mouth, consists of scattered willow thickets and alder and provides good bank habitat. Much of the stream course has been denuded of willow cover by excessive cattle grazing and by brush removal for hay meadow development.

Land use in the Flint Creek basin is diverse. Mining, grazing, hay production, hydropower and recreation are all important uses. Philipsburg, Maxville and Hall are communities located along Flint Creek.

Fred Burr Creek, a Flint Creek tributary, carries significant mercury from an old ore milling operation. Fish in the vicinity of the mill site exceed health recommendations for mercury in foodstuffs. It is likely that mercury is also contributing to impairment of ecosystem health downstream from Fred Burr Creek.

STREAM NAME: Flint Creek

STREAM REACH: #1. From the Georgetown Lake outlet to the confluence of Boulder Creek - 28.0 miles.

LOCATION: Sec. 6, T5N, R13W to Sec. 4, T8N, R13W

GAME FISH SPECIES PRESENT: Brown trout, rainbow trout, cutthroat trout, bull trout, brook trout, mountain whitefish

FISHERY:

Fish species present in this reach include bull, cutthroat, rainbow, brown and brook trout. Mottled sculpin, mountain whitefish and coarsescale suckers are common. A 500-yard section of Flint Creek below Philipsburg was sampled in 1977. The section contained a mixed population of trout, with brown trout being the dominant species. Trout densities were estimated at 877 per mile.

WILDLIFE:

Species inhabiting this reach include elk, moose, and mule and whitetail deer. Hungarian partridge, ruffed, blue and Franklin's grouse utilize streamside habitats. Furbearers include mink, muskrat and beaver.

Little waterfowl usage occurs on this reach of Flint Creek.

WETTED PERIMETER:

Cross-sectional measurements were made in an approximate 50-foot section of Reach #1 located upstream from the confluence of Boulder Creek (NE, NW, SW Sec. 4, T8N, R13W). Three riffle cross-sections were established in this section. The WETP program was calibrated to field data collected at flows of 72.2, 106.0 and 127.0 cfs.

The relationship between wetted perimeter and flow from a composite of the three riffle cross-sections is shown in Figure 25. Lower and upper inflection points occur at approximate flows of 35 and 50 cfs, respectively.

WHY FLOW IS NECESSARY:

The requested flow is necessary to maintain the existing, diverse resident trout population and to provide flows for lower sections of Flint Creek which are often severely dewatered; and to help protect the habitat of those wildlife species present which depend on the stream and its riparian zone for their food, water and shelter.

FLOW REQUEST:

January 1 - December 31--50 cfs (36,198 A.F./yr.)

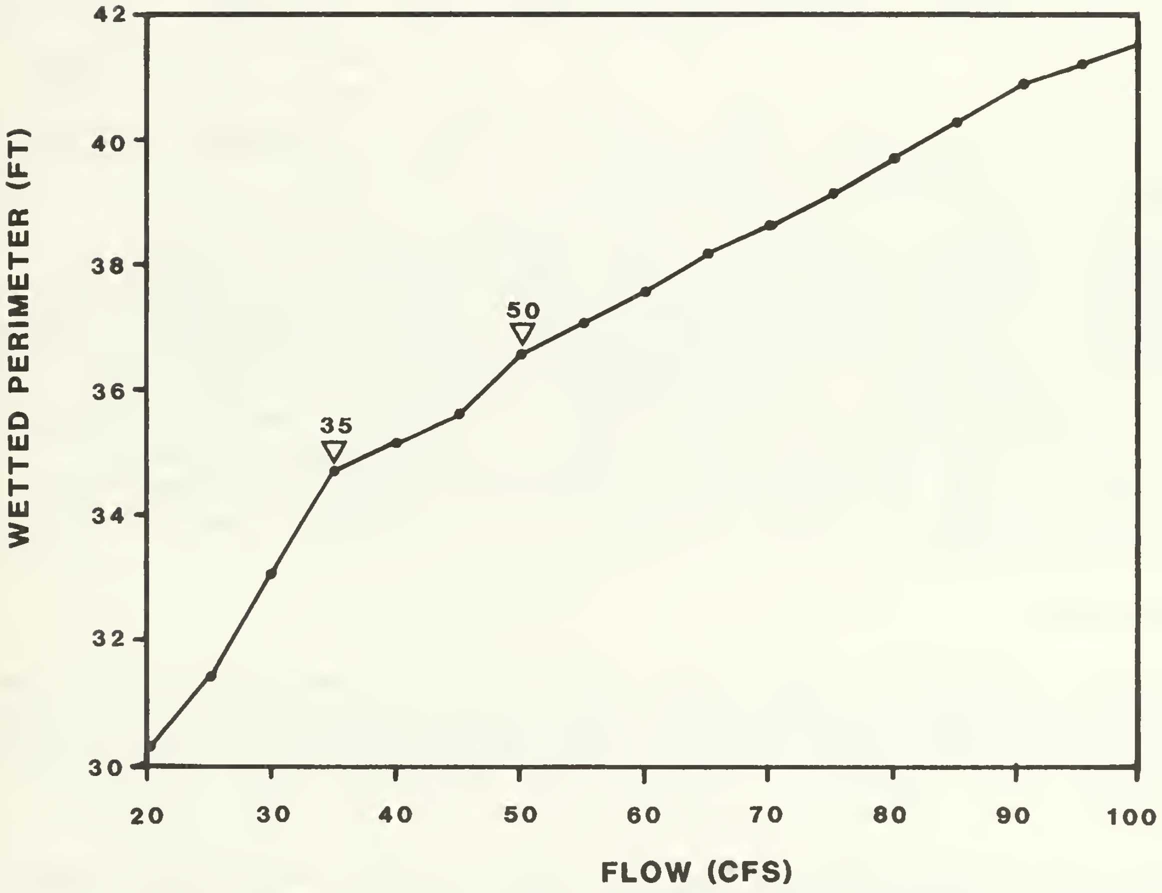

Figure 25. The relationship between wetted perimeter and flow from a composite of 3 riffle cross-sections in Flint Creek above the confluence of Boulder Creek.

STREAM NAME: Flint Creek

STREAM REACH: #2. From the confluence of Boulder Creek to the mouth - 15.7 miles.

LOCATION: Sec. 4, T8N, R13W to Sec. 6, T10N, R12W

GAME FISH SPECIES PRESENT: Brown trout, rainbow trout, westslope cutthroat trout, bull trout, mountain whitefish

FISHERY:

Flint Creek fish populations were estimated in 1983 in a section beginning on the New Chicago road. This section lies within mixed pasture and hay land. Bank stability is fair. Considerable erosion occurs on areas where willow cover is absent. The substrate is rubble, gravel and silt. A layer of fine sediment covers much of the substrate and appears to be the result of poor land management. Summer flows are often turbid due to irrigation return flow.

Bull, cutthroat and brown trout were caught in this section, with browns comprising 99% of the trout population. Sculpins were common, and coarsescale suckers were extremely abundant. Mountain whitefish were present in large numbers. The brown trout population was estimated to be 567 fish per mile. Some individuals were nearly 18 inches in length. While a population of this magnitude can support a substantial fishery, it is probably much less than the stream is capable of producing. The apparent lack of trout production is probably due to siltation and dewatering.

WILDLIFE:

Species inhabiting the reach area are elk, moose and mule deer. A substantial white-tailed deer herd utilizes the willow bottoms. Hungarian partridge, ruffed, blue and Franklin's grouse utilize streamside habitats. Furbearers include mink, muskrat and beaver.

The more open areas of Flint Creek provide desirable waterfowl habitat. Considerable migrant use occurs and there is some reproduction.

WETTED PERIMETER:

Cross-sectional measurements were made in a 90-foot section of Reach #2 located approximately 1.5 miles upstream from the confluence with the Clark Fork River (SE, Sec. 7, T10N, R12W). Three riffle cross-sections were established in this section.

The WETP program was calibrated to field data collected at flows of 214.9, 224.4 and 381.3 cfs.

The relationship between wetted perimeter and flow from a composite of the three riffle cross-sections is shown in Figure 26. Lower and upper inflection points occur at approximate flows of 35 and 60 cfs, respectively.

WHY FLOW IS NECESSARY:

The requested flow is necessary to maintain the existing resident trout population and to help protect the stream from future water withdrawals which would contribute to an already severe problem in the lower section of the reach; and to help protect the habitat of those wildlife species present which depend on the stream and its riparian zone for food, water and shelter.

FLOW REQUEST:

January 1 - December 31--45 cfs (32,578 A.F./yr.)

NOTE: The inflection point shown at 45 cfs in Figure 26 was picked because stream dewatering and other habitat abuses in this stream reach do not justify a flow request of 60 cfs. On the other hand, habitat conditions are good enough that a flow request of only 35 cfs is not justified.

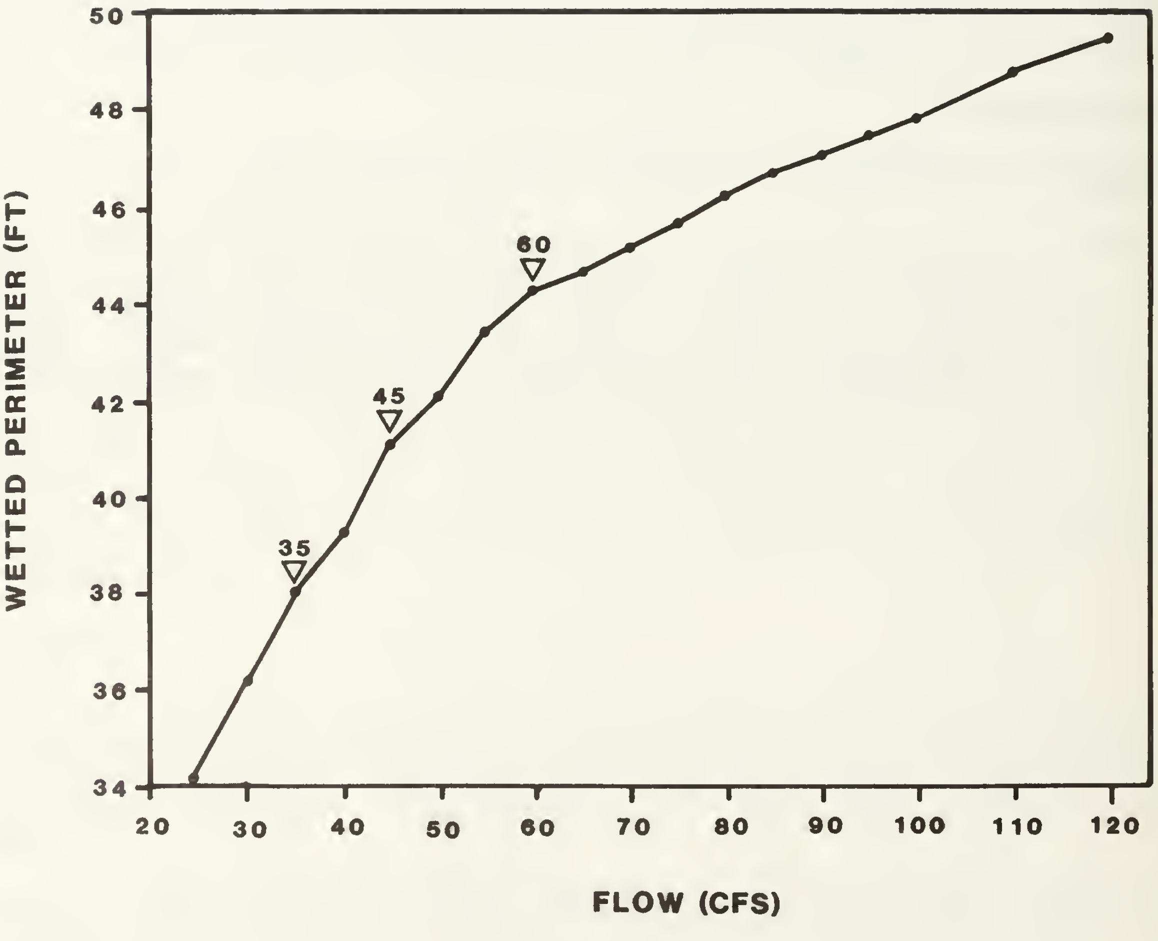

Figure 26. The relationship between wetted perimeter and flow from a composite of 3 riffle cross-sections in Flint Creek near its mouth.

STREAM NAME: Boulder Creek

STREAM REACH: From the headwaters to the mouth - 13.4 miles.

LOCATION: Sec. 27, T7N, R12W to Sec. 4, T8N, R13W

DESCRIPTION OF STREAM REACH:

Boulder Creek is a clear, precipitous mountain stream. It originates in the Flint Creek Range and flows northwestward to its mouth at Flint Creek about a mile below Maxville. It has a drainage area of more than 70 square miles. The substrate throughout the length of the stream is composed largely of boulder and rubble with small areas of gravel. Boulder Creek was largely ignored for placer gold because of the very large size of streambed material from which the stream gets its name. Transparency is normally high, making the stream of considerable visual attractiveness.

The drainage basin is rather uniform with steep mountainous terrain closely approaching the streamcourse. Primary uses are logging, mining, recreation and limited livestock grazing. Past mining activities have caused moderate damage to Boulder Creek, but the impact on water quality is currently unknown. Two small communities, Princeton and Maxville, are located along the stream. Irrigation withdrawals are minor at this time.

Tributaries to Boulder Creek include South Boulder, Swamp Gulch, Copper, Granite, Royal Gold, and Little Gold creeks, and Princeton Gulch. About a dozen small mountain lakes are located in the headwaters.

GAME FISH SPECIES PRESENT: Brown trout, cutthroat trout, bull trout

FISHERY:

A section located about 2.5 miles upstream from Princeton was sampled. Here the stream is relatively pristine, with excellent riparian vegetation. The substrate is boulder and rubble with interspersed gravel, and the width is about 15 feet.

Fish species present in this area are bull and cutthroat trout. Populations of both species in excess of 6.0 inches were sparse. Adults of both species were present. A number of juveniles were also present. Visual examination of the cutthroats suggested that they may represent the genetically pure westslope subspecies. The low population densities observed are probably the result of a combination of low seasonal temperatures and reduced solar radiation, which contribute to low productivity. The presence of bull and cutthroat trout, both native species whose numbers and geographic distribution are in serious decline, increases the fisheries value of this reach. The use of this section by upstream migrant spawners has not been determined.

Another section lower down on Boulder Creek was sampled at the USGS gaging station about 1/2 mile above the junction with Flint Creek. In this area riparian vegetation is primarily willow, alder and cottonwood. Banks are generally stable with nearly solid stands of the above species. The substrate is boulder and rubble with occasional patches of apparently granitic sand.

Fish species found in this section were bull, cutthroat and brown trout. Westslope cutthroat were the most abundant species. The population of all trout species was estimated to be 317 fish per mile. It seems likely that numbers of fish from Flint Creek may utilize Boulder Creek as a spawning site. Bull trout reportedly ascend the stream, but the timing of the sample was not condusive to their capture.

WILDLIFE:

Boulder Creek is used by beaver and mink. Game birds associated with the stream are blue, Franklin's and ruffed grouse. Big game species include mule deer, elk, moose and mountain goat in the upper reach and whitetail deer in the lower reach.

Only minimal waterfowl use is expected in this small, swift stream.

WETTED PERIMETER:

Cross-sectional measurements were made in an approximate 250-foot section of Boulder Creek located near its confluence with Flint Creek (W½ Sec. 4, T8N, R13W). Five riffle cross-sections were established in this section. The WETP program was calibrated to field data collected at flows of 10.7 and 79.0 cfs.

The relationship between wetted perimeter and flow from a composite of the five riffle cross-sections is shown in Figure 27. Lower and upper inflection points occur at approximate flows of 10 and 20 cfs, respectively.

WHY FLOW IS NECESSARY:

The requested flow is necessary to maintain the integrity of the existing, (but declining) native westslope cutthroat and bull trout populations; to provide good quality water to Flint Creek and, in turn, to the Clark Fork River for dilution of mining pollutants; and to help protect the habitat of those wildlife species which depend upon the stream and its riparian zone for food, water and shelter.

FLOW REQUEST:

January 1 - ~~September~~ December 31--20 cfs (14,479 A.F./yr.)

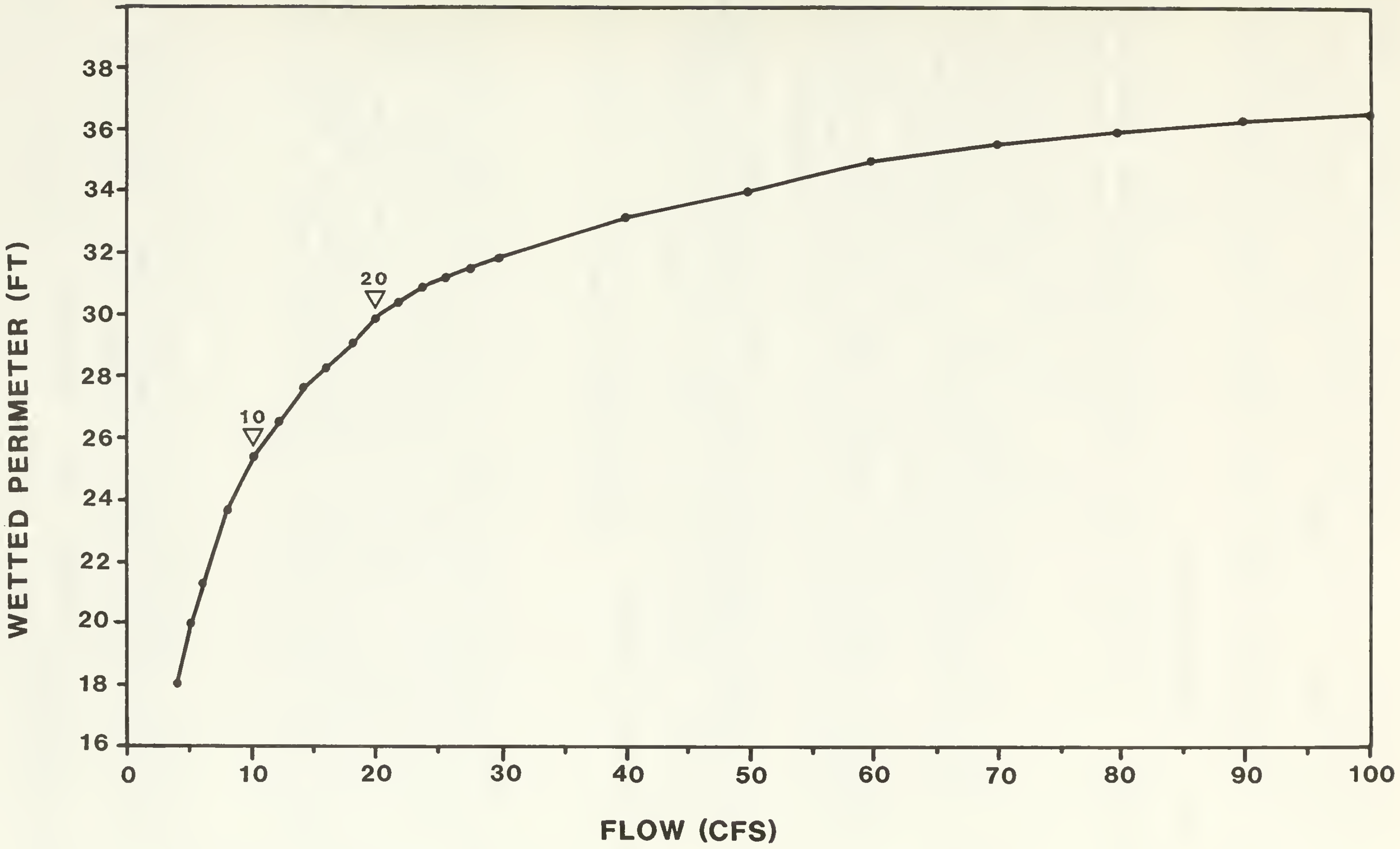

Figure 27. The relationship between wetted perimeter and flow from a composite of 5 riffle cross-sections in Boulder Creek.

STREAM NAME: North Fork of Flint Creek

STREAM REACH: From the headwaters to Georgetown Lake - 7.5 miles.

LOCATION: Sec. 14, T6N, R13W to Sec. 7, T5N, R13W

DESCRIPTION OF STREAM REACH:

The North Fork of Flint Creek enters Georgetown Lake on the eastern shore. It drains 13.4 square miles in the southwestern portion of the Flint Creek Range. The majority of its course is precipitous, and most of the substrate is rubble and gravel. Riparian vegetation along the upper stream is well developed. In the reach just above Georgetown Lake, the gradient decreases and an alder-willow association borders the creek. Streambanks in this area are stable and well vegetated, providing good trout cover. Gravel and fines predominate the stream substrate.

A DFWP spawning station is located about 200 yards above the lake. Spawning rainbows and rainbow X cutthroat hybrids were formerly trapped, and the eggs taken for hatchery rearing.

Land use in the drainage includes livestock grazing and timber harvest, but the most important function is recreation. Numerous recreational homes dot the basin, and the area is intensively used by tourists. A popular ski resort is located in the area.

GAME FISH SPECIES PRESENT: Rainbow trout, cutthroat trout, bull trout, brook trout

FISHERY:

The North Fork of Flint Creek is the only major spawning tributary to Georgetown Lake other than Stuart Mill Creek. It has in the past been the site of spawning by large runs of rainbows and rainbow cutthroat hybrids. A remnant run of rainbows still occurs in the spring. New management practices at Georgetown may further enhance existing rainbow spawning runs. Large numbers of brook trout enter the North Fork of Flint Creek in the fall, and this locality may provide much of the brook trout recruitment to Georgetown Lake.

WILDLIFE:

The stream and its associated riparian zone are used by mule and white-tailed deer, moose, elk and small game. Game bird use includes ruffed, Franklin's and blue grouse.

The lower stream provides some waterfowl habitat in the alder-willow sections.

WETTED PERIMETER:

Cross-sectional measurements were made in an approximate 38-foot section located near the confluence with Georgetown Lake (SE,NE,SE Sec. 7, T5N, R13W). Three riffle cross-sections were established in this section. The WETP program was calibrated to field data collected at flows of 4.0, 5.3 and 80.2 cfs.

The relationship between wetted perimeter and flow from a composite of the three riffle cross-sections is shown in Figure 28. Lower and upper inflection points occur at approximate flows of 3 and 6 cfs, respectively.

WHY FLOW IS NECESSARY:

The requested flow is necessary to maintain existing resident trout populations as well as to maintain the integrity of this stream for spawning populations of adult trout from famous Georgetown Lake; and to help protect the habitat of those wildlife species present which depend upon the stream and its associated riparian zone for food, water and shelter.

FLOW REQUEST:

January 1 - December 31--6 cfs (4,344 A.F./yr.)

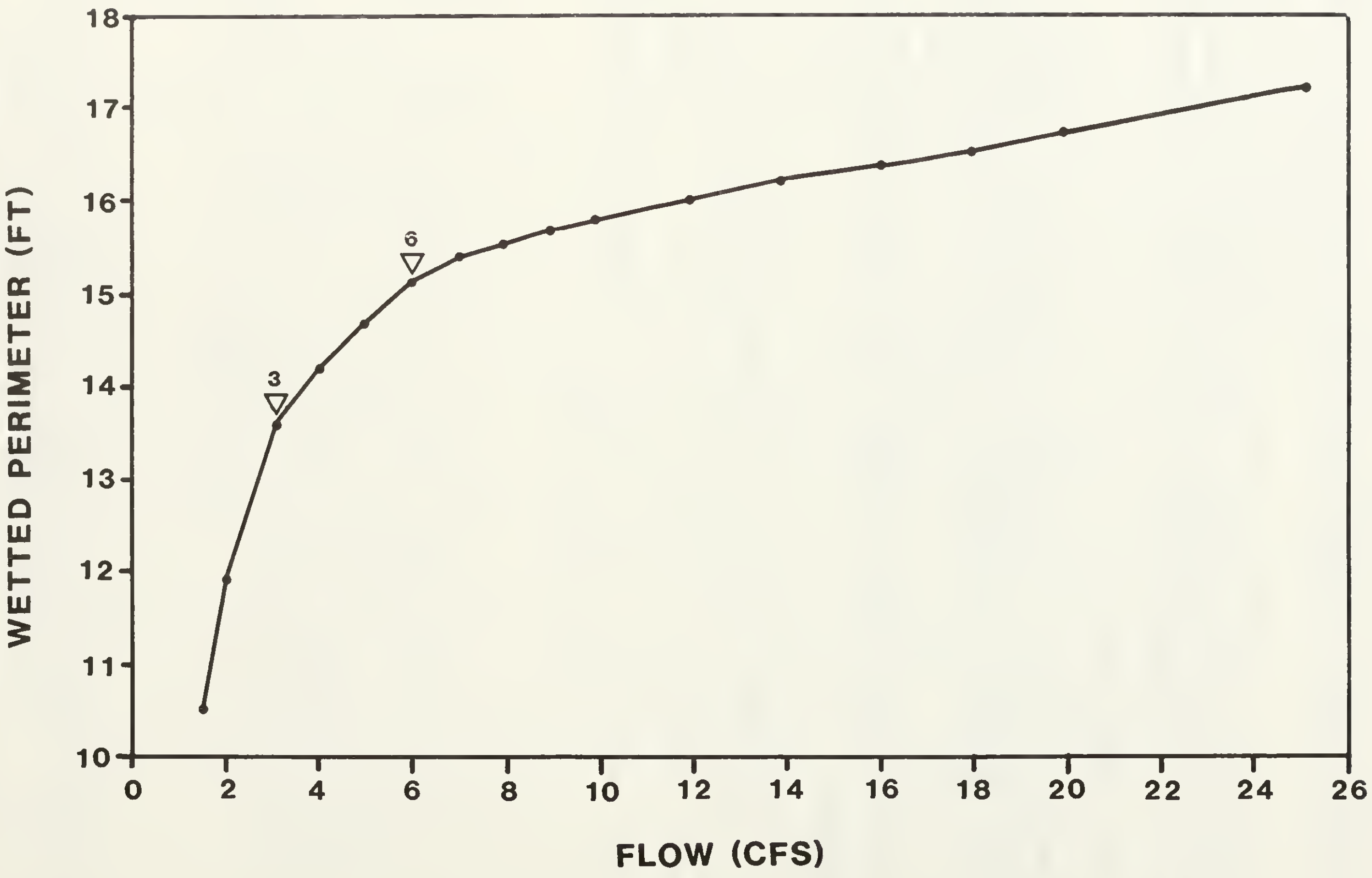

Figure 28. The relationship between wetted perimeter and flow from a composite of 3 riffle cross-sections in the North Fork of Flint Creek.

STREAM NAME: Stuart Mill Creek

STREAM REACH: From its origin to Georgetown Lake - 0.3 mile.

LOCATION: Sec. 19, T5N, R13W

DESCRIPTION OF STREAM REACH:

Stuart Mill Creek is a small spring-fed tributary to Georgetown Lake. Its total length is about 1/3 mile, and it has a very low gradient. The drainage area is in excess of 12 square miles. It originates primarily from spring flow and follows a sinuous course to its outlet in Stuart Mill Bay of Georgetown Lake. Alder, willow and sedges comprise the bulk of streamside vegetation. Stream width is from 10 to 30 feet, and the substrate is gravel, sand and silt.

GAME FISH SPECIES PRESENT: Rainbow trout, brown trout, kokanee

FISHERY:

The stream supports brook trout on a year-round basis, but its primary significance is that of a spawning tributary for fish migrating from Georgetown Lake. Large numbers of kokanee, brook trout and rainbow trout use the stream for spawning. The stream's contribution of juvenile fish to Georgetown Lake is very important to the Georgetown fishery. Stuart Mill and the North Fork of Flint Creek are the only spawning tributaries entering Georgetown Lake.

WILDLIFE:

Due to its spring source, Stuart Mill Creek provides substantial waterfowl habitat. The creek's warmer water temperature serves to provide open water in Stuart Mill Bay when other parts of the lake are frozen over and unavailable to waterfowl. The creek thus provides significant waterfowl habitat for both migrants and breeders.

The stream provides small but important habitat for wildlife. Muskrats and mink are common, and riparian areas are used by ruffed, blue and Franklin's grouse as well as white-tailed deer and moose.

WETTED PERIMETER:

The WETP program could not be used because of the constant-flow nature of this spring creek. There were also no riffles to use as measuring sites. However, a mid-September flow of 14.5 cfs was measured in this stream.

Because of the low potential for future water use from this creek, its high value as a spawning stream for Georgetown Lake, and its spring creek characteristics, a flow of 14 cfs is recommended for year-round maintenance of fish habitat. This is probably the majority of the flow of Stuart Mill Creek.

WHY FLOW IS NECESSARY:

The requested flow is necessary to maintain the existing resident brook trout population, but more importantly, to allow the stream to continue to be an important spawning stream for Georgetown Lake; and to help protect the habitat of those wildlife species which depend upon the stream and its associated riparian zone for food, water and shelter.

FLOW REQUEST:

January 1 - December 31--14 cfs (10,136 A.F./yr.)

STREAM NAME: Harvey Creek

STREAM REACH: From the confluence of Otter Creek to the mouth - 14.6 miles.

LOCATION: Sec. 36, T10N, R16W to Sec. 16, T11N, R14W

DESCRIPTION OF STREAM REACH:

Harvey Creek arises in the John Long Range and flows northeastward to its confluence with the Clark Fork about two miles west of Bearmouth. The drainage basin is 40.1 square miles. An irrigation diversion dam approximately 150 feet from the mouth of the stream can totally dewater the remaining stretch of the stream.

The upper drainage is primarily U.S. Forest Service land. Access is limited to much of the area by difficulties in crossing privately-owned lands in the lower section. Logging, grazing and recreation are important uses in the upper drainage, while uses in the lower reaches are primarily agricultural.

GAME FISH SPECIES PRESENT: Brown trout, rainbow trout, cutthroat trout, bull trout, brook trout

FISHERY:

Harvey Creek was sampled by electrofishing from its mouth at the Clark Fork upstream 500 feet to the interstate highway crossing. The section is bordered by hay fields and averages about 10 feet in width. The gradient is rather low with a fair amount of woody riparian vegetation (mostly willow and alder). The substrate is silt and gravel which is overlain in places by board structures apparently intended to reduce erosion. Submerged aquatic vegetation is common. The section is rather straight and appears to have been channelized in the past.

Harvey Creek supports rainbow, brown, brook, cutthroat and bull trout (a species of special concern) in this section. Longnose dace, mottled sculpin and coarsescale suckers were also present. Trout larger than six inches were not abundant. The estimated number of all trout species was 127 per mile. Large numbers of young brook, cutthroat and brown trout were observed in the section, and it is probable that they enter the Clark Fork and contribute to the fishery there. A collection was made in October, 1984 to determine the presence of fall spawning trout ascending the stream from the Clark Fork. No evidence of a run was found. The diversion dam mentioned above apparently prevents the stream from being used by spawning migrants from the Clark Fork and, therefore, seriously reduces the potential contribution to mainstem recruitment.

WILDLIFE:

Harvey Creek is used by white-tailed deer, raccoon, beaver, mink and muskrats in its lower section.

Due to the small size of Harvey Creek, it is unlikely to be of significant value to nesting waterfowl. It is probably utilized by a fair number of late migrants in the lower section due to the apparent influx of groundwater and resultant late freeze-up.

WETTED PERIMETER:

Cross-sectional measurements were made in a 12-foot section located near the confluence with the Clark Fork River (NW,SW, Sec. 16, T11N, R14W). Three riffle cross-sections were established in this section. The WETP program was calibrated to field data collected at flows of 3.6, 3.7 and 40.3 cfs.

The relationship between wetted perimeter and flow from a composite of the three riffle cross-sections is shown in Figure 29. Lower and upper inflection points occur at approximate flows of 2 and 5 cfs, respectively.

WHY FLOW IS NECESSARY:

The requested flow is necessary to maintain the existing resident trout population, some of which likely contribute to the fishery of the Clark Fork River; to provide good quality water to the Clark Fork River for dilution of toxic mining wastes; and to help protect the habitat of those wildlife species which depend upon the stream and its associated riparian zone for food, water and shelter.

FLOW REQUEST:

January 1 - December 31--3 cfs (2,172 A.F./yr.)

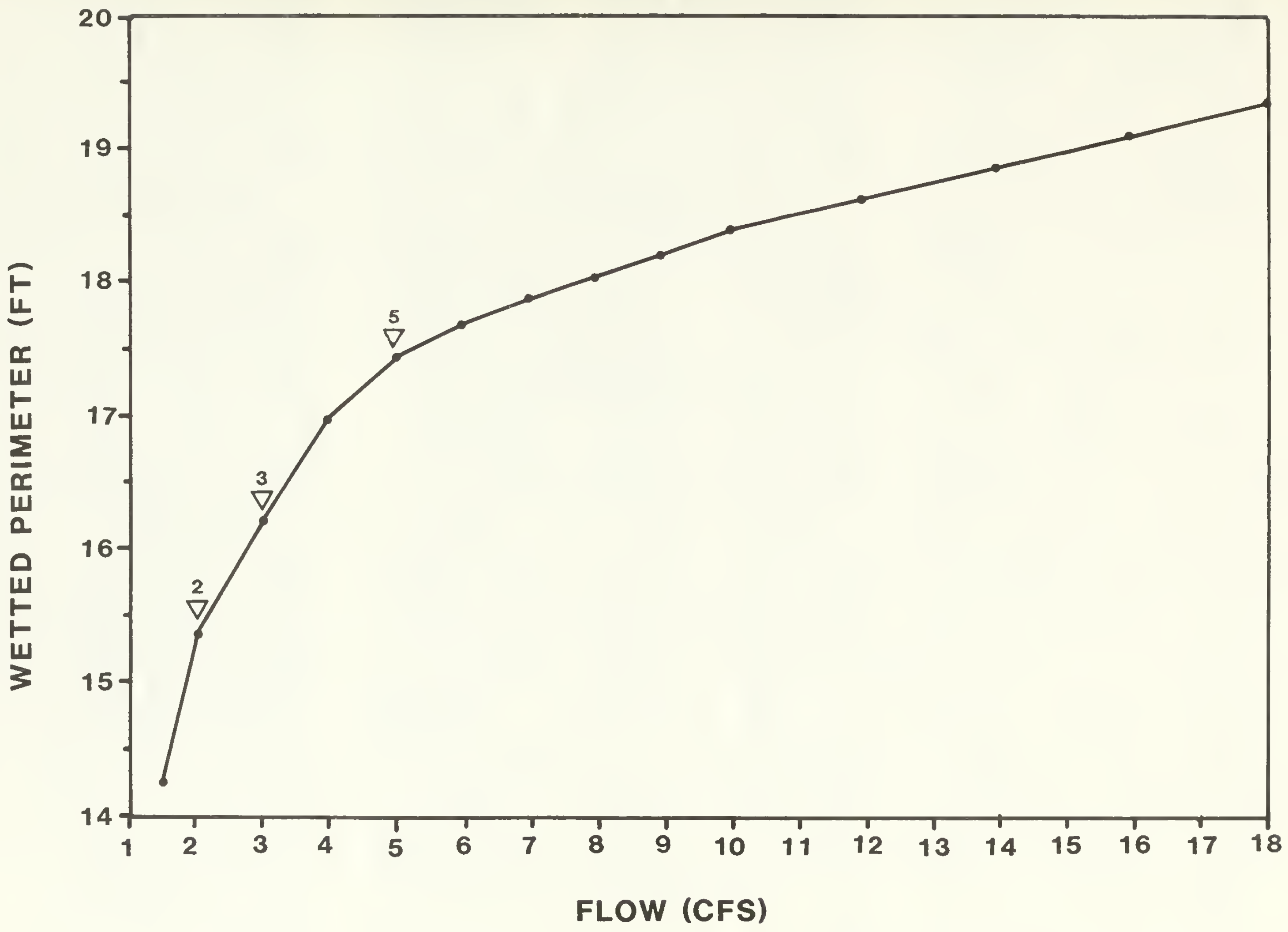

Figure 29. The relationship between wetted perimeter and flow from a composite of 3 riffle cross-sections in Harvey Creek.

6. Water Quality Considerations

a. Introduction

This section discusses existing water quality conditions and the relationship of streamflow to the present water quality situation in the Clark Fork River. Following this discussion, instream flow requests for certain tributary streams are made specifically to help maintain water quality in the Clark Fork. However, it should be understood that these flow requests do not, in all cases, require greater amounts of water in the stream channel than have already been requested for fish habitat purposes. There will be some overlap in water quantities between the two requests. The purpose of these additional requests is to prevent further dewatering of these tributary streams that would occur if new diversionary water use permits were issued.

Maintaining adequate instream flows in a river like the Clark Fork is beneficial to water quality because adequate flow provides the river with a greater capacity to assimilate pollutants. Montana's Water Quality Act was enacted to protect the waters of the state and the beneficial uses provided by clean water. These uses include, but are not limited to, the production of fish and other aquatic life. Part of our request for reservation of instream flow is based on the need to prevent further degradation of water quality conditions that affect fish production in the Clark Fork. Such degradation would diminish the opportunity for, and quality of, water-based recreation.

Existing point and non-point pollution sources cause water quality criteria to be exceeded in the Clark Fork River. Parameters in the Clark Fork that sometimes do not meet accepted criteria for protection of aquatic life include dissolved oxygen, water temperature, and several metals, of which copper is judged to be the most significant.

The major tributaries entering the upper Clark Fork River between Warm Springs Creek and Bonner have water which, for the most part, is of higher quality than water in the mainstem Clark Fork. These tributaries dilute the Clark Fork River and improve its water quality over that which would exist without the benefit of dilution. Reductions in tributary streamflow during intervals when criteria are presently exceeded in the mainstem will result in more frequent exceedances of water quality criteria and in exceedances that are of a greater magnitude.

b. Water Quality Standards and Criteria

The terms water quality standards and water quality criteria are often confused and incorrectly used interchangeably. The word standard applies to limits which are established by authority (usually by law) on the level of change in water quality that is allowed. Montana's Water Quality Standards adopted by the Board of Health and as provided for in Montana's Water Quality Act are such an example. Criteria, on the other hand, are scientific information used to judge what impacts would be expected from a particular change in water quality. Criteria, unlike standards, are not laws, however, they are usually used in reaching a judgment as to what the standard or law should be. The Environmental Protection Agency periodically publishes "national criteria documents" that summarize the scientific information that is available on important pollutants. These documents contain recommendations as to what numerical limits (usually concentrations) should be placed on pollutants in order to protect specified benefical uses of water (such as protection of aquatic life). The criteria referred to in this reservation request are concentrations required to protect aquatic life as recommended in these national criteria documents.

Standards

Montana's Water Quality Standards vary depending on the beneficial uses being protected. Segments of the Clark Fork River and its tributaries within the geographical limits of this flow reservation request have six designated water use classifications, including: A-1, A-Closed, B-1, C-1, C-2 and E. Some of these use classifications are designed to protect drinking water (A-1, A-Closed) and offer no more protection to aquatic life than the B-1 classification. Water quality standards that apply to the C-1 classification in the Clark Fork offer less protection to aquatic life than the B-1 classification.

The goal of the Federal Water Pollution Control Act is to "restore and maintain the chemical, physical, and biological integrity of the nation's waters." Consistent with this goal, and for purposes of discussing this reservation request, it is assumed that a B-1 classification is achievable at some point in the future for the entire Clark Fork River, including those reaches presently assigned less protective use classifications. This goal may take many years to achieve. However, in the context of the flow reservation, it is realistic to think in terms of long-term goals, since reserved instream flow is a long-term form of protection for the river.

Criteria

Copper:

Criteria to protect aquatic organisms from chronic copper toxicity were derived from experiments where fish were exposed to copper during all (or at least during the critical stages) of their life cycle. Rainbow trout exposed to copper during an early life-stage test experienced reduced embryo survival and lowered standing crop at concentrations of 19 μg/l (0.019 mg/l) and greater (McKim *et al*. 1978). Similar experiments with brown trout showed effects at 31 μg /l (0.031 mg/l) and above. Rainbow trout embryos are much more sensitive to copper than those of brown trout; all rainbow trout embryos died at 37 μg/l (0.037 mg/l), while 555 μg/l (0.555 mg/l) was required to produce the same effect in brown trout.

Brook trout are more sensitive to copper than either rainbow or brown trout (Sauter *et al*. 1976, McKim *et al*. 1978); larval survival was reduced at concentrations as low as 5 μg/l (0.005 mg/l).

Chronic toxicity of copper to invertebrates has also been tested. The lowest concentration producing toxic effects on scud (*Gammarus sp.*) was 6.1 μg/l (0.0061 mg/l) (Arthur and Leonard 1970), while that for water flea (*Daphnia magna*) was 9.5 μg/l (0.0095 mg/l) (EPA 1980).

Based on the above experimental results, a chronic copper toxicity criterion of 5.6 μg/l (0.0056 mg/l) was established (EPA 1980).

Dissolved Oxygen:

Criteria for dissolved oxygen are complicated because different species of fish have varying oxygen requirements. The EPA Redbook (1976) recommends a criterion of 5 mg/l. However, Davis (1975) reviewed the dissolved oxygen literature and concluded that dissolved oxygen concentrations below 9.75 mg/l can damage salmonid eggs and larvae. (The Montana standard for dissolved oxygen under the B-1 classification is 7.0 mg/l.)

Water Temperature:

Fish are cold blooded and cannot regulate their body temperature. Consequently, their metabolic rates and abilities to grow are influenced by the temperature of their surroundings. Rate of growth is thus one of the most sensitive indicators of temperature stress.

Different species of fish have varying temperature requirements and metabolic rates. Consequently, temperature criteria are species specific. The criterion for most species is the temperature above which the energy used to search for, capture and metabolize food is greater than the amount of energy realized from consumption of the food. This is the temperature above which growth is no longer possible and occurs at approximately 66°F in both rainbow (EPA 1976) and brown trout (Elliot 1975). Temperatures above 66°F occur occasionally in almost all of Montana's trout streams. However, the condition becomes more damaging to the fish as the frequency and duration of exceedances increase.

c. Metals in the Clark Fork Drainage

Metals in the Clark Fork River are the result of mining activities that occurred in its headwaters over approximately the last hundred years. Historically, mine tailings processed in the Butte-Anaconda area were dumped into Silver Bow Creek or its floodplain. Over the years these tailings have been eroded and redistributed throughout Silver Bow Creek and portions of the upper Clark Fork River (Hydrometrics 1983). The seriousness of the problem is exemplified by the fact that Silver Bow Creek is ranked nationally as a hazardous waste "Superfund" cleanup site.

Rice and Ray (1984) showed that copper, arsenic and cadmium are present in the Clark Fork River floodplain in concentrations one to two orders of magnitude greater than in typical, unpolluted soils. A very small part of this is due to airborne pollutants from smelting activites in the upper Deerlodge Valley; however, most of the floodplain contamination is due to deposition by the Clark Fork River of toxic wastes originating from upriver mine and smelter tailings.

Metals originating in Silver Bow Creek are presently treated in the vicinity of the Warm Springs ponds (Figure 30). Lime is added to the creek upstream of the ponds causing the pH to increase and resulting in precipitation of metals as hydroxides or carbonates; the ponds then act as settling basins for metal precipitates. This treatment system is effective for most of the year; however, beginning in January and lasting through ice-off, the discharge from the ponds contains copper concentrations that are higher than those recommended for protection of freshwater aquatic life.

It is important to distinguish between metals that originate in Silver Bow Creek upstream from the Warm Springs ponds and metals which arise from erosion of tailings present in the Clark Fork River floodplain because metals from these two sources are of greatest significance to the Clark Fork during different times of the year. Consequently, each must be treated differently with respect to this reservation request.

Several metals (including copper, cadmium, zinc and iron) exceed criteria for protection of aquatic life; however, copper is present at the highest concentrations relative to its toxicity. Consequently, only copper will be used to develop the argument for reservation of instream water. All references to metals concentrations are for total recoverable metals because national metals criteria are based on the total recoverable form.

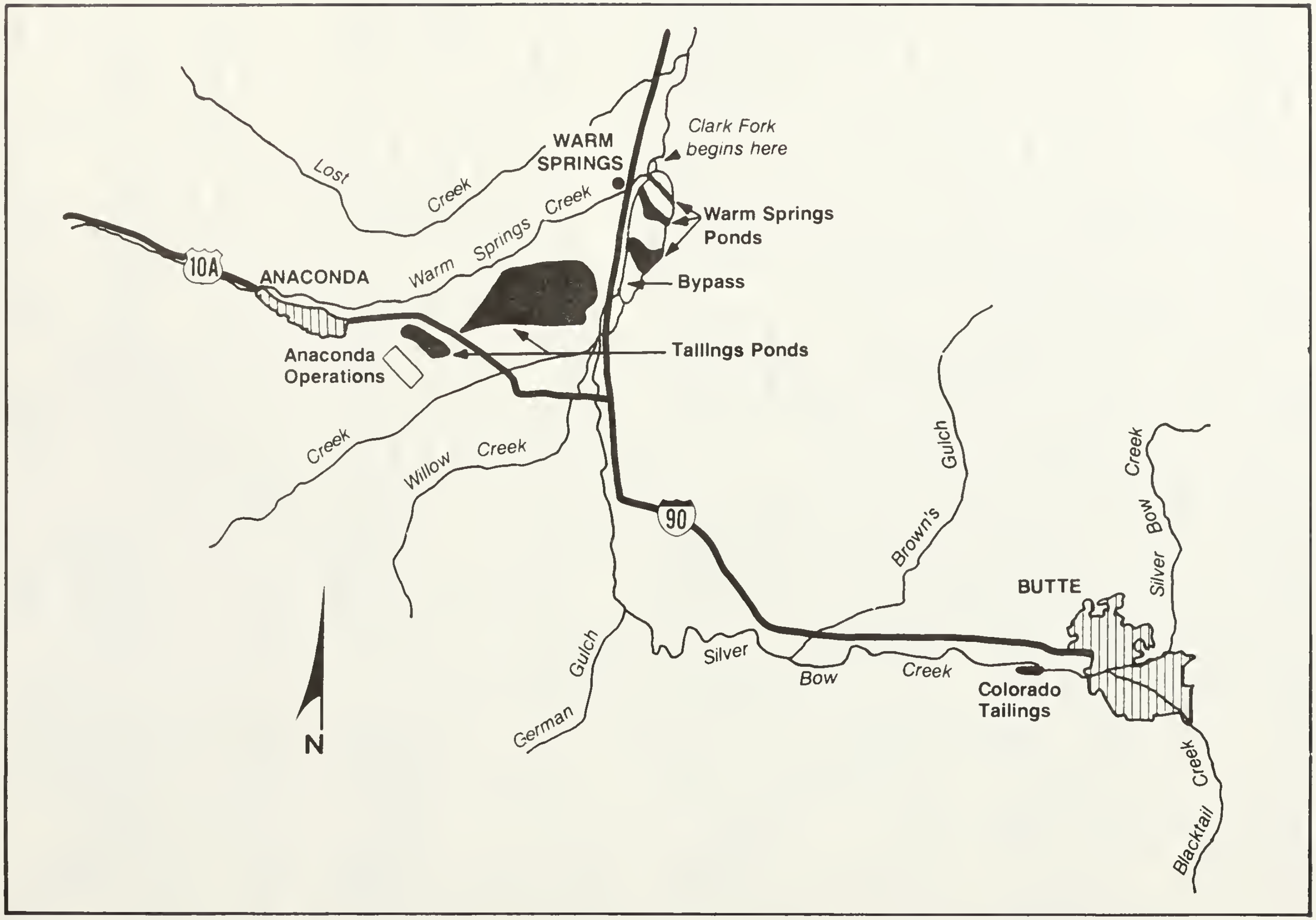

Figure 30. Upper Clark Fork River mining and smelter sites and mine waste treatment facilities.

Copper Criteria Exceedances (1975-1983)

Copper concentrations in the Clark Fork River (data collected by Water Quality Bureau, Montana Department of Health and Enviromental Sciences) between 1975 and 1983 are summarized according to how frequently the B-1 acute criteria for copper were exceeded during each of the months sampled (Tables 7 and 8).

These values were calculated using the formula $e^{(0.94\ [\ln\ (\text{hardness})]\ -\ 1.23)}$ that was given in the 1980 criteria document (EPA 1980).[1] The formula specifies that the softer the water the more toxic the metal, and, therefore, the more restrictive the criteria must be.

In general, criteria exceedances began in January and continued through July. Exceedances were not limited to the upper river. They also occurred in the reach between the Little Blackfoot River and Milltown Dam.

Copper Concentrations and Loading

Data on copper concentrations and copper loading in portions of the Clark Fork River Basin were summarized for 1983 and 1984 to (1) illustrate recent trends, (2) analyze sources of copper to the river, and (3) demonstrate why clean water tributaries are important for dilution of copper. The 1983 data were collected by the Department of Health and Environmental Sciences and consisted of monthly samples from the three major headwater sources (Warm Springs Creek, Mill-Willow bypass, and Pond-2 discharge) and three mainstem locations (downstream of Warm Springs Creek, at Deer Lodge, and immediately upstream of the Little Blackfoot River). The 1984 data, collected by the Department of Fish, Wildlife and Parks, consisted of weekly measurements between early April and mid-July of the same three headwater sources and from eight mainstem locations (Figure 31) (Mainstem locations that were added to the 1983 stations included: Near Kohrs, at Garrison, downstream from Gold Creek, upstream from Rock Creek, and several miles downstream from Rock Creek).

Loading is a term used to describe the quantity of material that passes a given sampling location over a specified interval of time. Loading is estimated by multiplying the concentration of the substance (in this case copper) by the discharge rate of the

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[1] Our calculations were made prior to release of the 1985 criteria document for copper. The 1985 document (EPA 1985) uses a different formula for calculating acute copper toxicity (based on hardness) that is slightly more restrictive than the 1980 document. However, this change has little or no bearing on our interpretation.

Table 7. Percentage of water samples which exceeded B-1 acute toxicity criteria for copper in the Clark Fork River between Warm Springs Creek and the Little Blackfoot River, 1975-1983.

Month	No. Samples	% Samples Exceeding B-1 Acute Copper Criteria
January	11	9
February	9	33
March	10	30
April	7	71
May	10	90
June	5	80
July	16	44
August	34	0
September	11	0
October	8	0
November	18	0
December	8	0

SOURCE: Montana Water Quality Bureau.

Table 8. Percentage of water samples which exceeded B-1 acute toxicity criteria for copper in the Clark Fork River between the Little Blackfoot River and Milltown Dam, 1975-1983.

Month	No. Samples	% Samples Exceeding B-1 Acute Copper Criteria
January	3	0
February	5	0
March	4	75
April	2	50
May	12	67
June	1	100
July	19	0
August	13	0
September	7	0
October	4	0
November	4	0
December	0	-

SOURCE: Montana Water Quality Bureau.

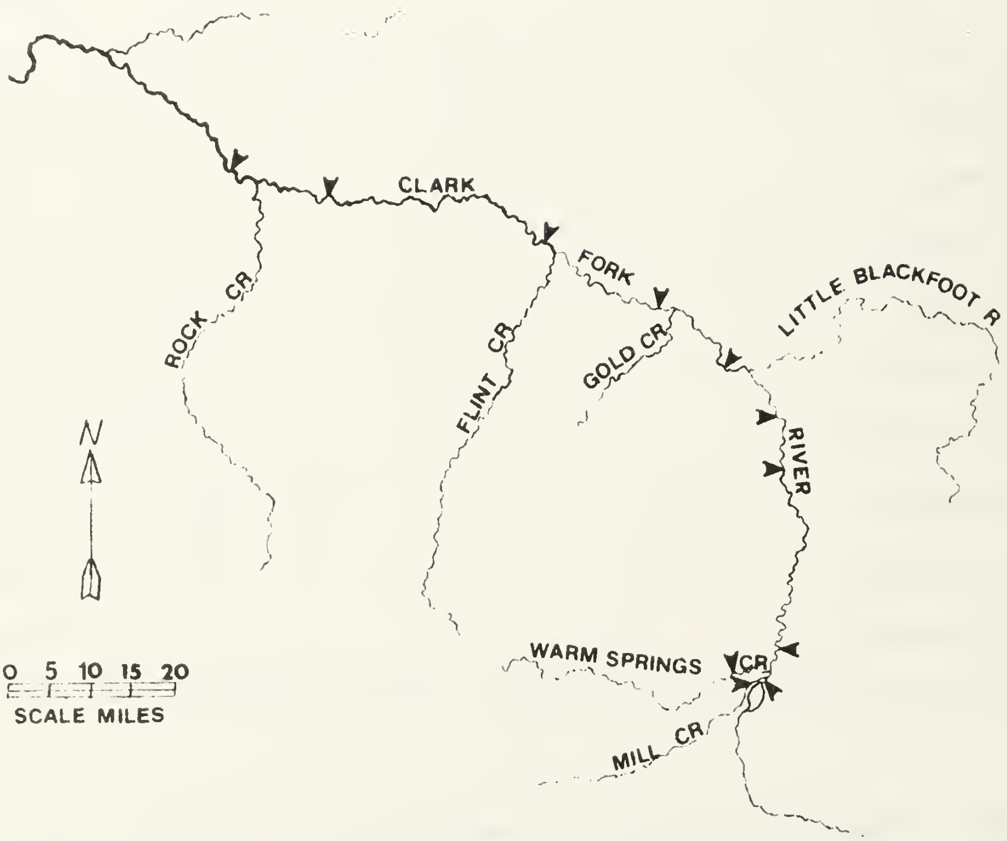

Figure 31. Upper Clark Fork River drainage showing stations where copper concentrations and flows were measured during 1984 (Some of the same stations were sampled in 1983).

river when the sample was collected (using appropriate conversion factors). Contributions of copper from various reaches can be estimated by comparing loading rates at different locations in the drainage.

Concentration trends

Concentrations of copper during both 1983 and 1984 were relatively low during the interval June through December in all three headwater sources (Pond-2, Mill-Willow, and Warm Springs Creek) (Figures 32 and 33) as well as in the mainstem (Figures 34 and 35). However, beginning in January, 1983, concentrations began to increase in both the Mill-Willow Bypass and in the Pond-2 discharge (Figure 32) which caused a similar increase in the mainstem (Figure 34). For the three headwater sources, copper concentration patterns during runoff were somewhat different in 1983 and 1984. In 1983 runoff commenced in early April and for the most part did not influence copper concentrations, although concentrations in the Pond-2 discharge decreased during runoff. At the three mainstem stations, the highest copper concentrations occurred in mid-May when discharge peaked (Figure 35).

During 1984, streamflows were somewhat higher in all of the headwater sources than in 1983 (Figures 32 and 33). Because of the higher streamflows at the beginning of runoff, untreated Silver Bow Creek water spilled over into the Mill-Willow channel causing copper concentrations to exceed 700 μg/l (0.700 mg/l) (Figure 33). This spike of copper was also evident at all eight mainstem locations that were sampled (Figures 35 and 36).

Several of the downstream sampling locations in the Clark Fork (primarily those between Deer Lodge and Rock Creek) experienced copper concentration peaks that did not occur near Warm Springs. These downstream peaks are probably due to erosion of tailings deposits located in the flood plain or possibly resuspension of bottom sediments that are rich in copper. Because of this, several of the downstream locations experienced elevated copper concentrations for a more extended time period than occurred at Warm Springs. Prolonged exposure to low but chronically toxic copper concentrations may be more biologically damaging than short exposures to high concentrations (as long as they are below the acute toxicity threshold). Consequently, fish living at several of the downriver stations probably experience more severe conditions with respect to copper than fish living immediately downstream of the Warm Springs Ponds.

During both 1983 and 1984 copper concentrations increased in Warm Springs Creek during runoff. The concentrations were not as high, or elevated for as long, as in the mainstem of the Clark Fork. Nevertheless, there appear to be tailings or other sources of metals in the Warm Springs Creek drainage.

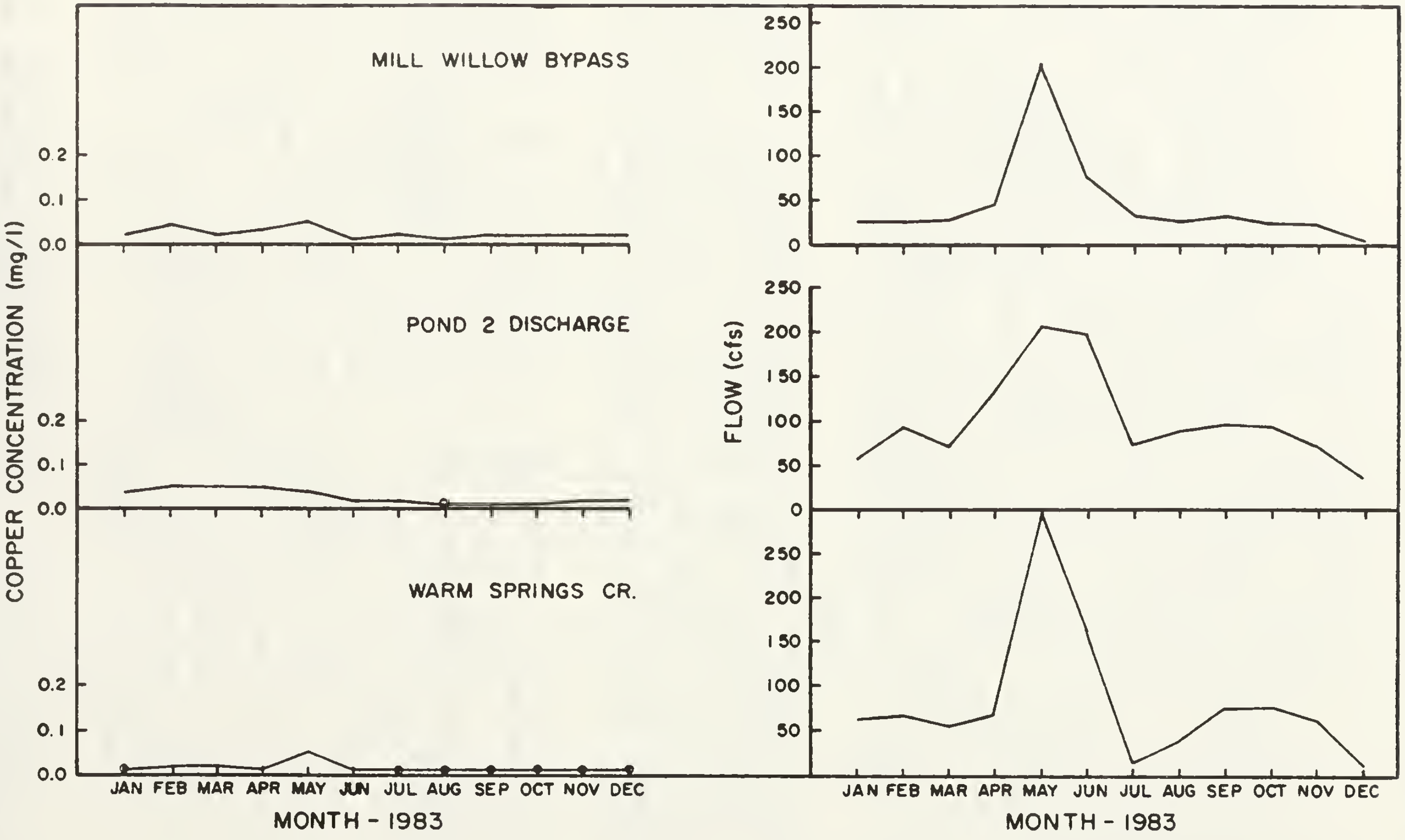

Figure 32. Copper concentrations and flows in the Mill-Willow Bypass, Warm Springs Pond-2 discharge, and Warm Springs Creek during 1983.

SOURCE: Montana Water Quality Bureau.

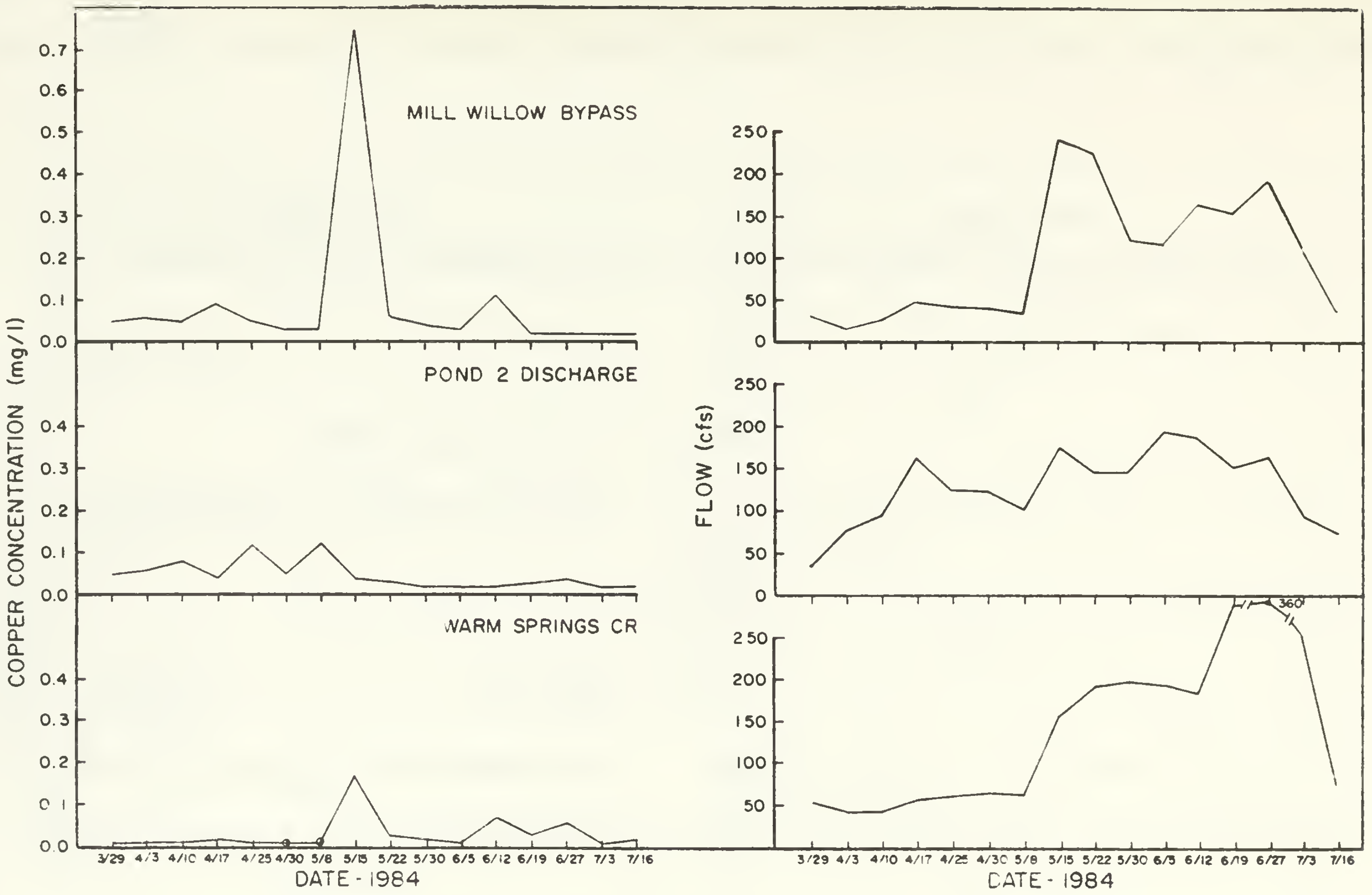

Figure 33. Cooper concentrations and flows in the Mill-Willow Bypass, Warm Springs Pond-2 discharge, and Warm Springs Creek between March 29 and ~~April~~ July 16, 1984.

SOURCE: Montana Water Quality Bureau.

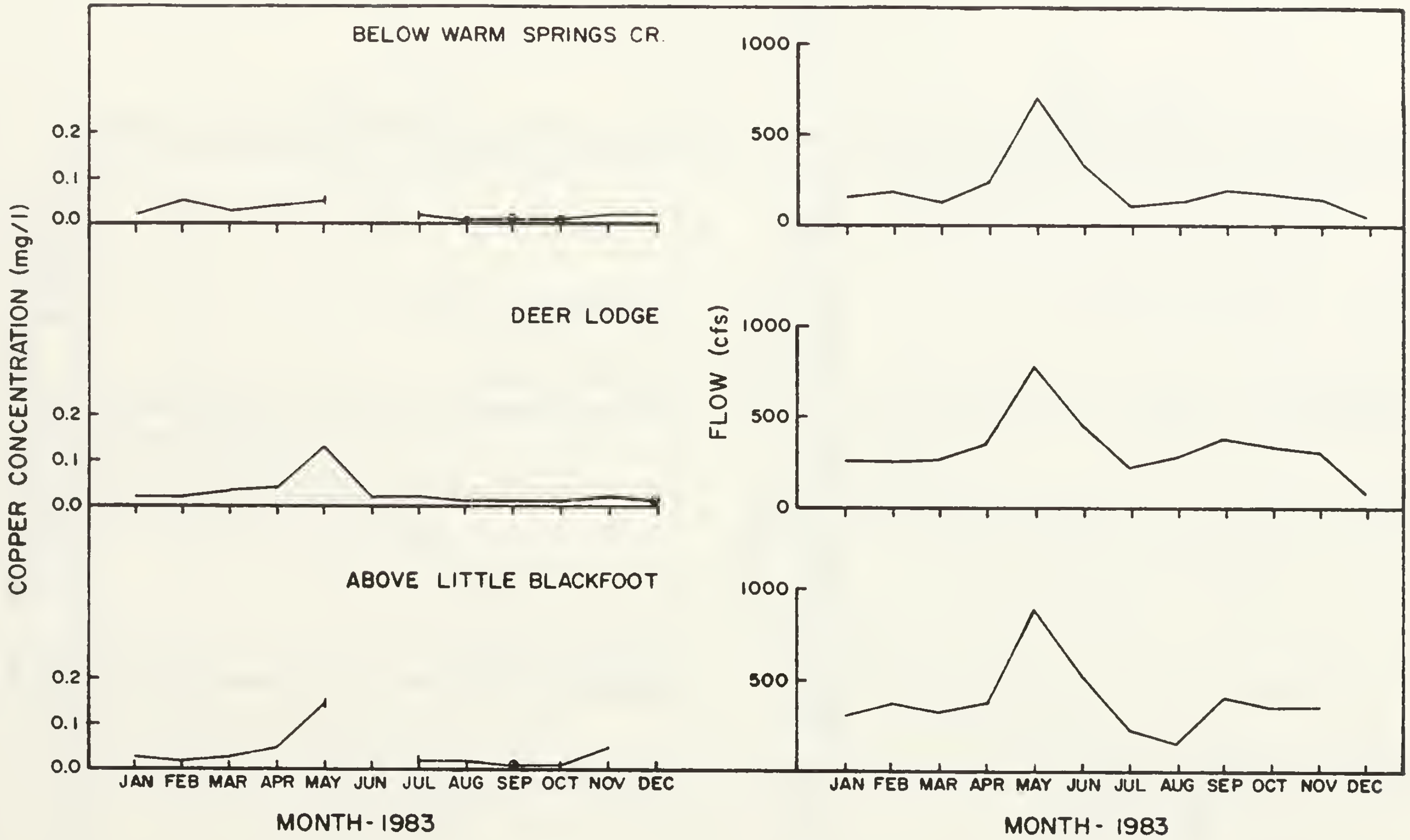

Figure 34. Copper concentrations and flows at three Clark Fork River locations during 1983.

SOURCE: Montana Water Quality Bureau.

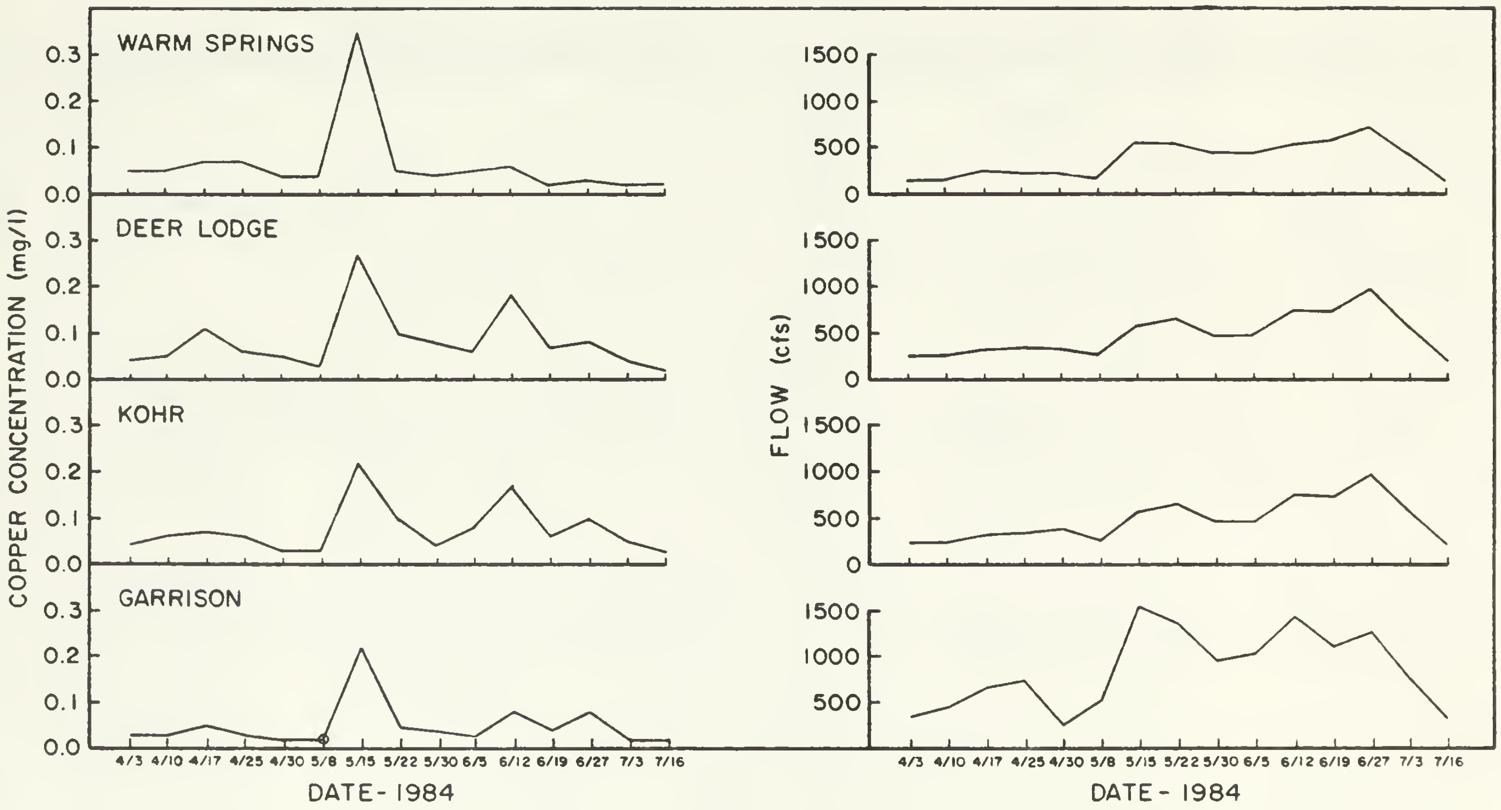

Figure 35. Copper concentrations and flows at four Clark Fork River locations between April 3 and July 16, 1984.

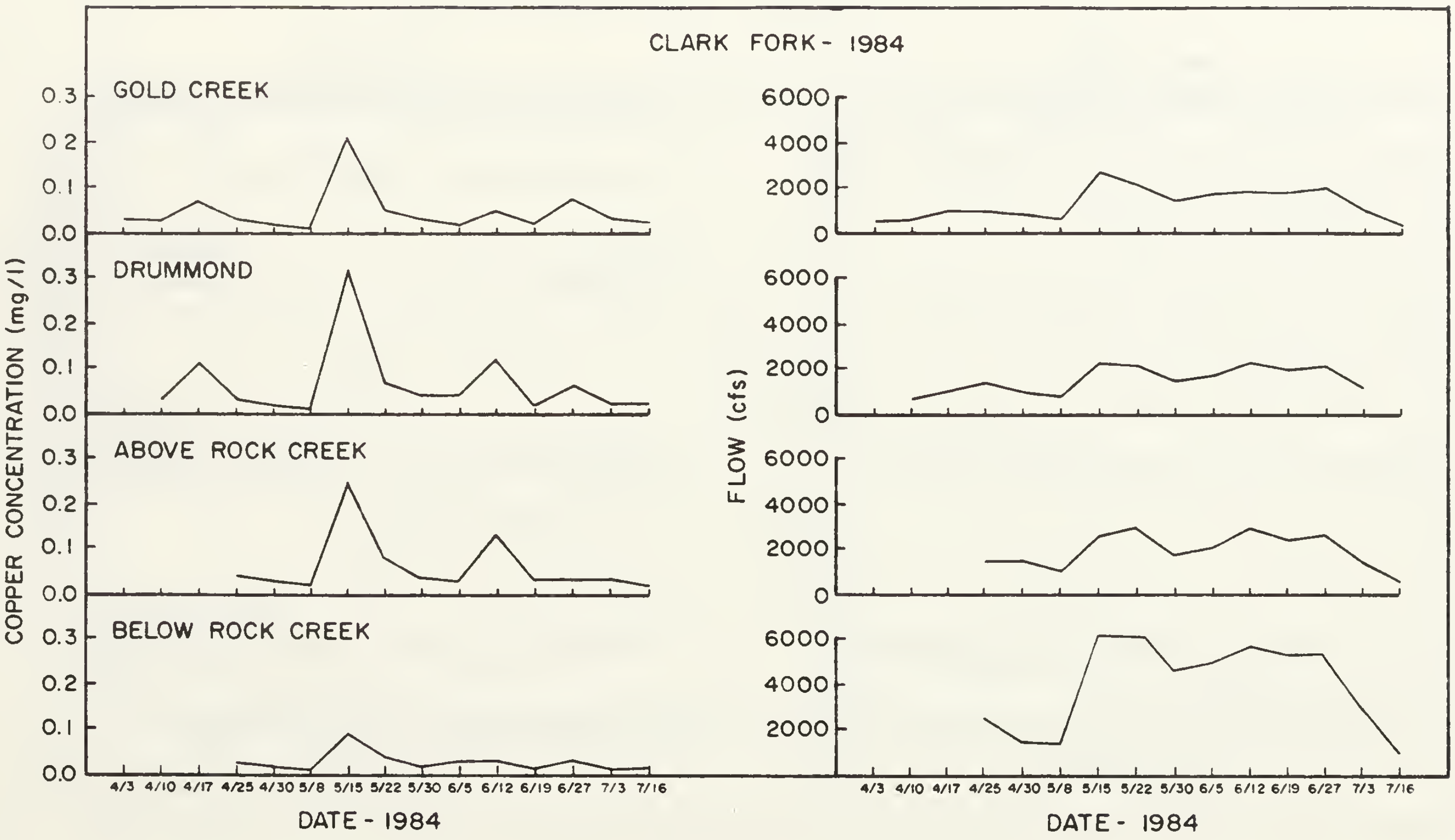

Figure 36. Copper concentrations and flows at four Clark Fork River locations between April 3 and July 16, 1984.

Copper concentrations were measurably lower downstream of the Little Blackfoot River and Rock Creek than upstream (Figures 37 and 38). Copper was not detected in either of those tributaries during 1984. Dilution from these clean water tributaries improves water quality in the river. During high flow periods, however, water quality downstream from the Little Blackfoot first improves, then deteriorates downstream--probably due to erosion of tailings. These clean water tributaries are extremely important because they provide relief from the higher copper concentrations that are present in the majority of the river.

Loading trends

Loading calculations for 1983 indicate that for every month, except May, the Pond-2 discharge contributed more copper to the Clark Fork than either the Mill-Willow bypass or Warm Springs Creek (Figure 39). During both 1983 and 1984, at the peak of runoff in May, contributions were greater from the Mill-Willow bypass and Warm Springs Creek (Figures 39 and 40). On May 15 of 1984 the bypassing of Silver Bow Creek into the Mill-Willow channel resulted in nearly 1,000 lbs/day of copper entering the upper Clark Fork.

Greater quantities of copper leave the Warm Springs ponds each month between January and April than from July through November. The higher concentrations during winter are not related to streamflow in the Clark Fork or to rate of discharge from the ponds, since both change very little between July and April (Figure 32). The reasons for the greater amounts of copper leaving the ponds during the winter are not clear. It appears that the ponds do not remove metals as efficiently during late winter as they do during the rest of the year. This could be due to reduced pond capacity caused by ice cover, difficulties in "liming" during the winter, development of chemical reducing conditions in the ponds that release metals from the sediments, or the sloughing of phytoplankton that have concentrated metals. Whatever the cause, a high percentage of the metals present in Clark Fork River water between January and March originates in the Pond-2 discharge. Depletion of flow (particularly in tributaries) below that which presently exists would increase metals concentrations in the river.

During both 1983 and 1984 copper loading in the mainstem Clark Fork River also varied with season (Figures 41 and 42). Expectedly, copper loading was greatest during runoff and tended to increase in the downstream direction. The latter is probably due largely to the erosion of tailings deposited along lower sections of the river.

Also in 1983, winter loading was higher at all mainstem stations (January through April) than in summer and fall (July through November) although streamflow was similar during both intervals. Dilution from clean water tributaries is particularly important

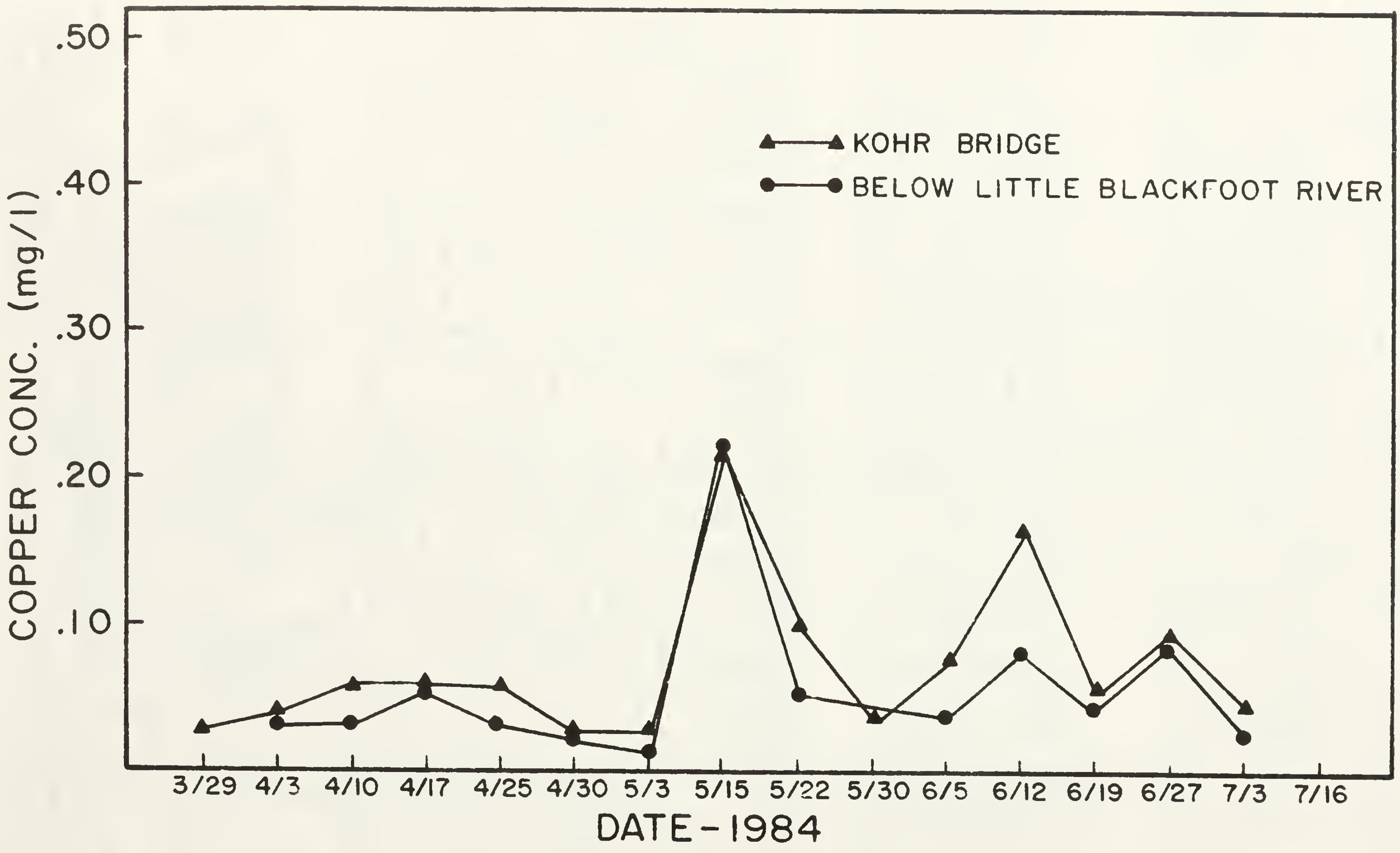

Figure 37. Comparison of copper concentrations at stations above and below the Little Blackfoot River (1984) demonstrating that dilution from the Little Blackfoot lowers copper concentrations in the Clark Fork River.

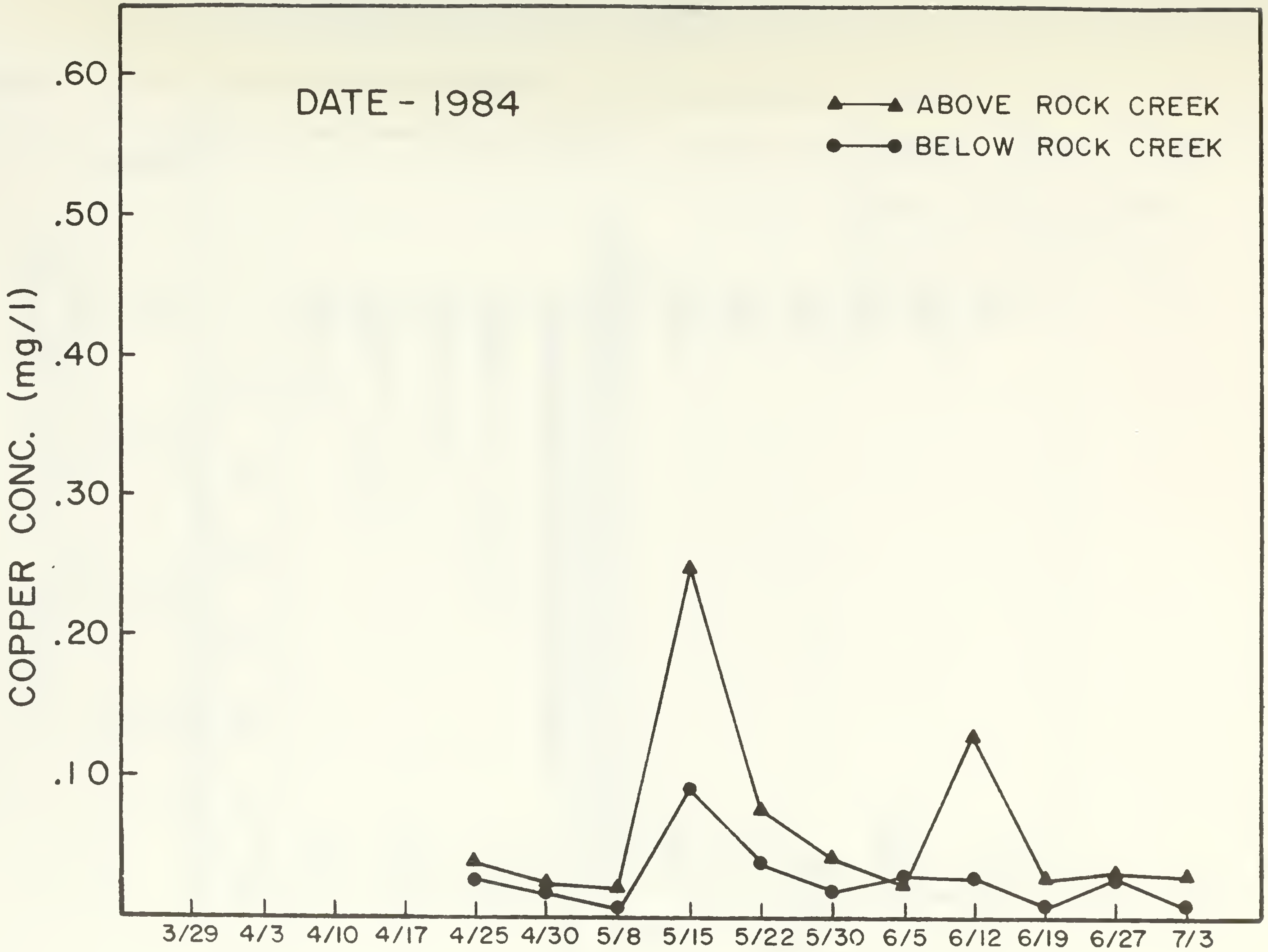

Figure 38. Comparison of copper concentrations at stations above and below Rock Creek (1984) demonstrating that dilution from Rock Creek lowers copper concentrations in the Clark Fork River.

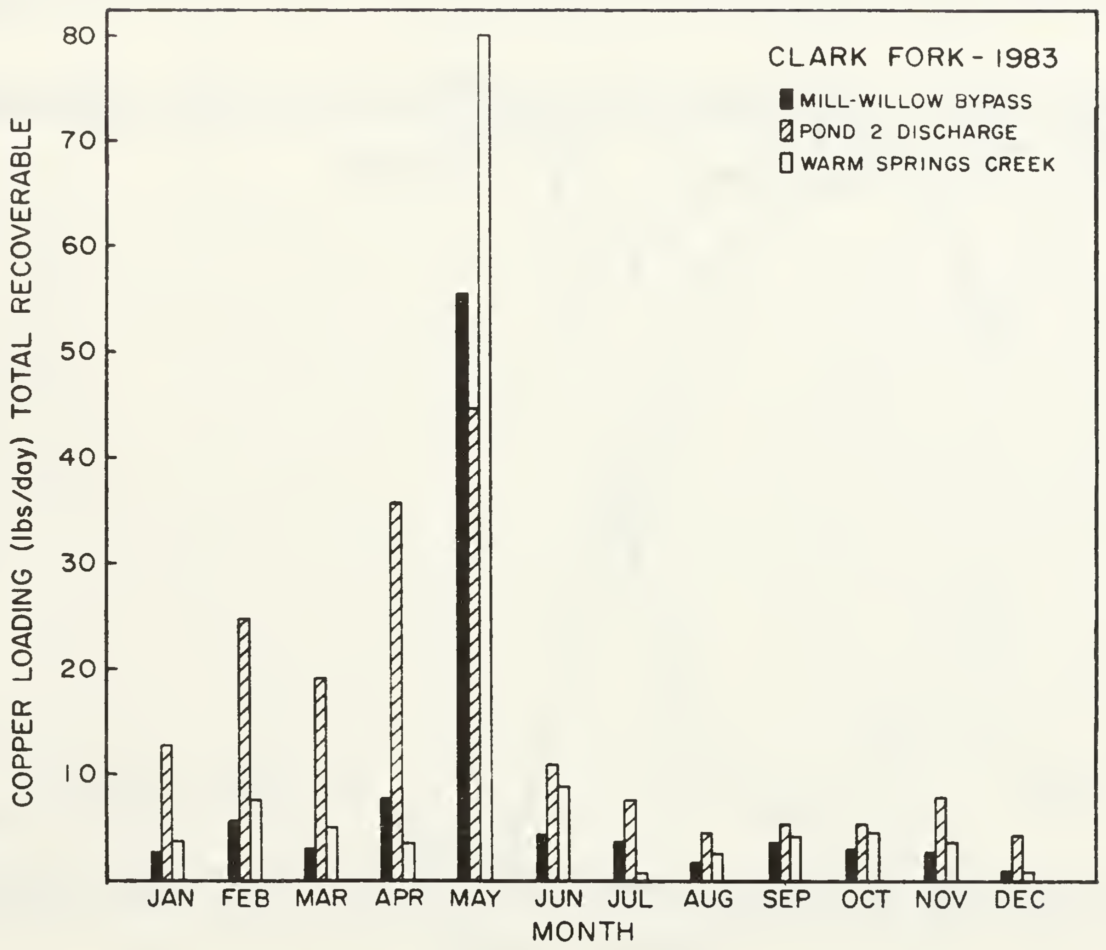

Figure 39. Copper loading in the Mill-Willow Bypass, Warm Springs Pond-2 discharge, and Warm Springs Creek during 1983.

SOURCE: Montana Water Quality Bureau.

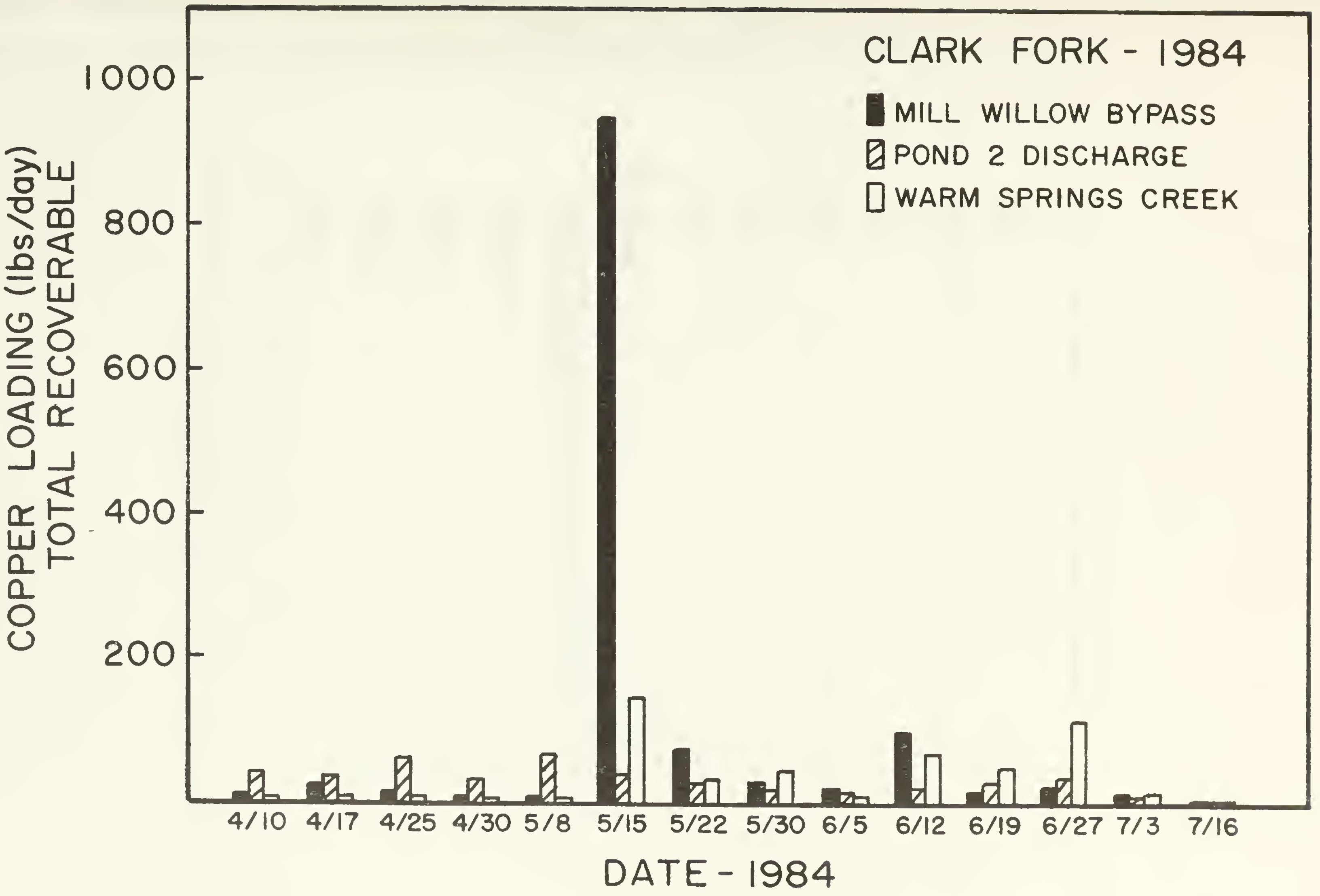

Figure 40. Copper loading in the Mill-Willow Bypass, Warm Springs Pond-2 discharge, and Warm Springs Creek between April 10 and July 16, 1984.

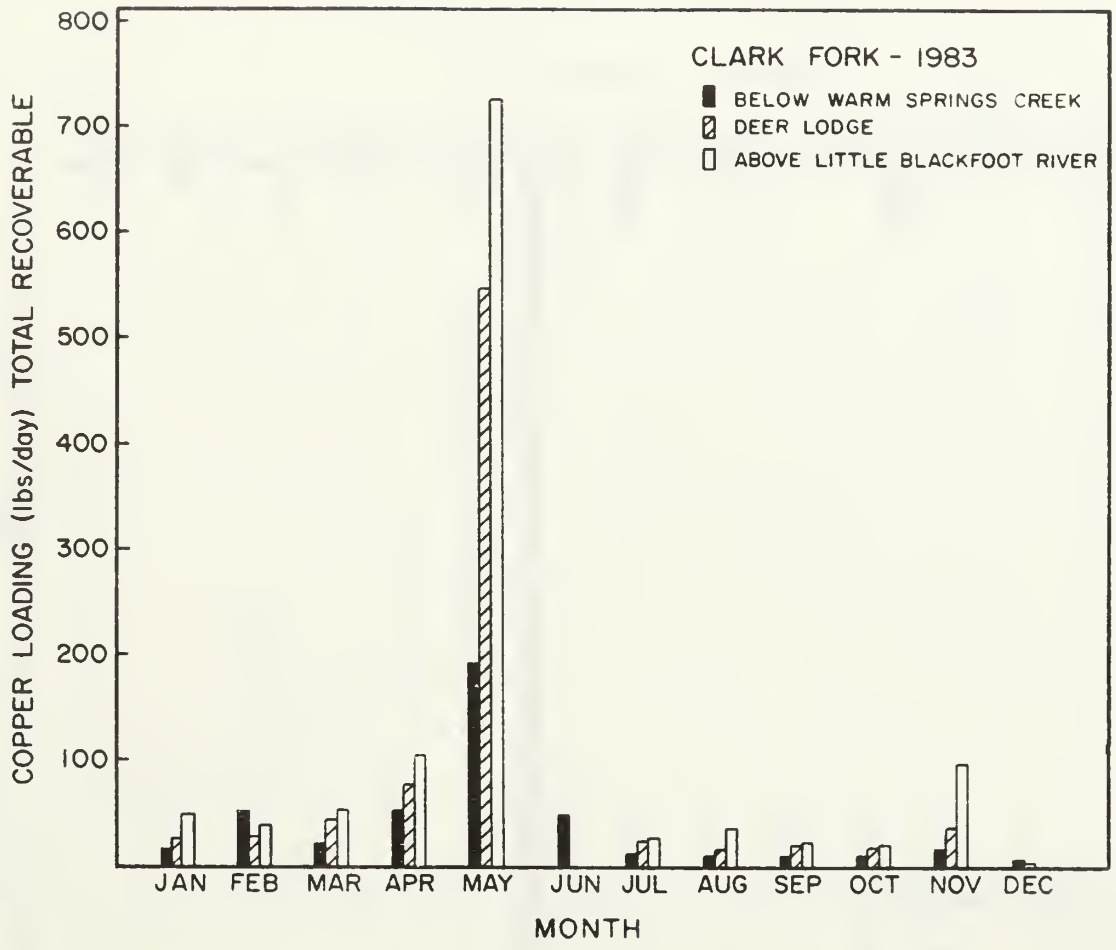

Figure 41. Copper loading at three Clark Fork River locations during 1983.

SOURCE: Montana Water Quality Bureau.

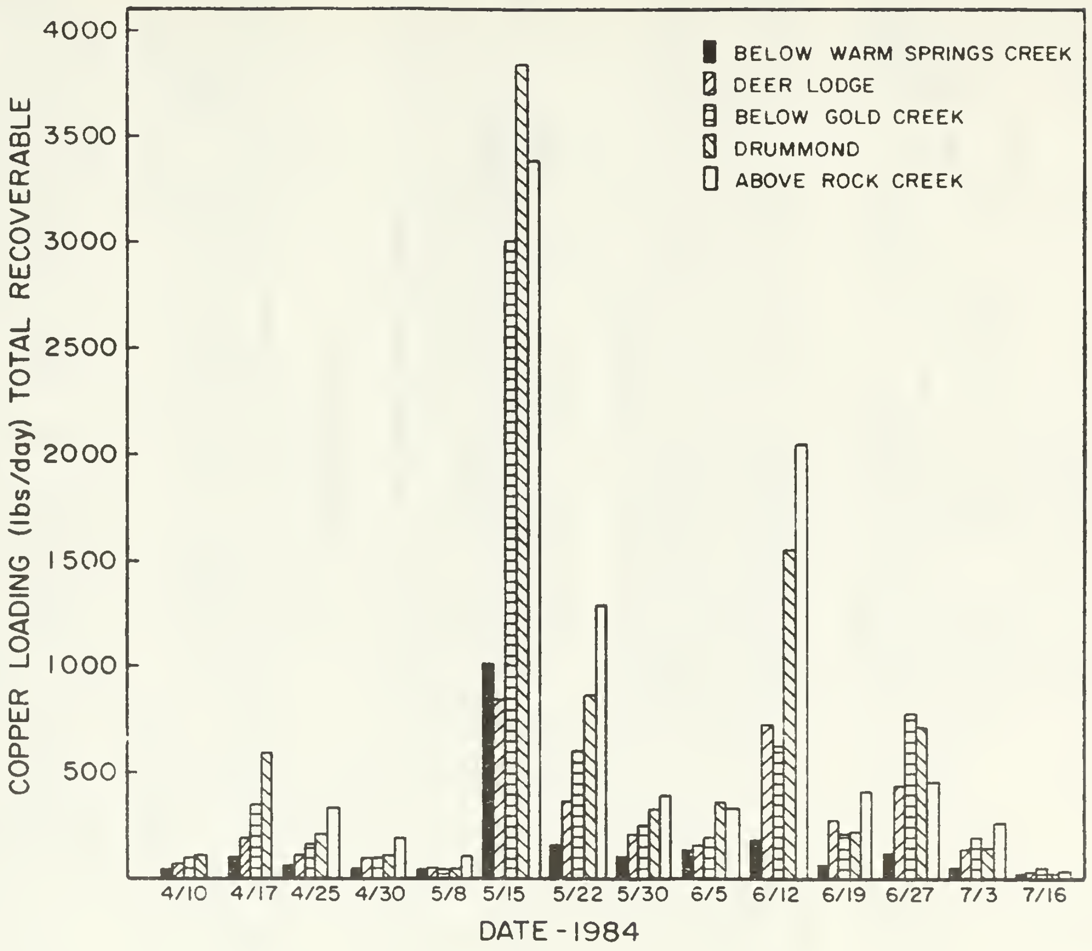

Figure 42. Copper loading at five Clark Fork River locations between April 10 and July 16, 1984.

over this winter period of high copper loading because brown trout embryos are incubating in the gravel during this time of year.

d. Dissolved Oxygen

Dissolved oxygen concentrations in a stream normally decrease overnight because aquatic macrophytes and algae produce oxygen only during the day (via photosynthesis). Normal overnight sags in oxygen concentration are exaggerated by the entrance of additional oxygen-demanding materials into the water.

A number of communities located along the upper Clark Fork River (including Butte, Anaconda, Warm Springs, Deer Lodge and Drummond) contribute treated domestic waste to the watershed. These materials continue to exert some oxygen demand on the river. Additionally, there are natural sources of oxygen - demanding substances that enter the river.

Few measurements have been made of dissolved oxygen in the upper Clark Fork River. Braico (1973) and Knudson and Hill (1978) measured overnight oxygen sags at several Clark Fork locations. Both recorded days in July and August when oxygen concentrations fell below 7.0 mg/l (Table 9) -- the threshold concentration specified in Montana's Water Quality Standards.

While the data base is limited, clearly the river receives oxygen-demanding substances, and periods now exist where oxygen concentrations sag below Montana's Water Quality Standards. An instream flow reservation will prevent further loss of dilution capacity and almost certainly will prevent more frequent and severe excursions below dissolved oxygen standards.

e. Water Temperature

Water temperatures near and above 66°F impose metabolic demands on trout that cannot be offset by consuming food; consequently, growth is limited near and above this temperature. High water temperatures are doubly stressful in that water holds less oxygen as temperature increases.

Between 1977 and 1982, the DFWP maintained continually recording thermographs at several locations in the Clark Fork River. Temperature was monitored during one or more years at Deer Lodge, Gold Creek, Bearmouth, Bonita and Clinton. All stations had some days in June, July and August when the median daily water temperature exceeded 66°F (Table 10). Thus, fish in the river are already experiencing temperature stress during the summer.

Higher stream discharges keep water cooler by increasing water depth (thereby increasing insulation from the sun and air) and by accelerating water velocity (providing less time for the water to warm after it enters the drainage). Further reduction in flow

Table 9. Locations and dates of dissolved oxygen measurements in the Clark Fork River when concentrations below 7.0 mg/l were recorded.

Location	Date	Minimum recorded (mg/l)
Deer Lodge	August 3, 1973	5.9
Drummond	August 3, 1973	6.0
Bonita	August 3, 1973	5.2
Turah	August 3, 1973	6.0
Deer Lodge	July 21, 1976	6.8
Deer Lodge	July 21, 1977	6.0
Bonita	July 21, 1977	5.9
Deer Lodge	August 4, 1977	6.4
Bonita	August 4, 1977	6.8
Deer Lodge	August 18, 1977	6.2
Bonita	August 18, 1977	6.3

Table 10. Number of days in June, July and August (1977-82) when median daily water temperature exceeded 66°F at several locations along the Clark Fork River.

Locations	Years of data	Number of exceedances	
		Total	Per Year
Deer Lodge	3	17	5.6
Gold Creek	4	85	21.3
Bearmouth	5	106	21.2
Bonita	5	115	23.0
Clinton	3	86	28.6

SOURCE: Thermograph records from MDFWP, Region 2, Missoula.

during July and August would tend to increase water temperatures in the river.

f. Relationship of Flow to Water Quality

The following points summarize the relationship of flow to water quality in the Clark Fork River:

(1) Several metals are present in the Clark Fork River at concentrations that exceed criteria for protection of aquatic life. Of these, copper is present at the highest concentrations relative to its toxicity and is probably the most limiting.

(2) Major sources of metals to the Clark Fork River are tailings deposits located both upstream of the Warm Springs ponds and downstream along the floodplain. The former, for the most part, receive the benefit of treatment at the Warm Springs ponds, while the latter receive no treatment and are subject to erosion, particularly during high flows.

(3) As a result of (1) and (2) above, copper criteria exceedances occur during some seasons of the year in the entire upper Clark Fork.

(4) The period of the year when chronic metals criteria are most frequently exceeded is January through July. Metals criteria exceedances that occur prior to runoff are, to a large extent, due to metals that originate from the Warm Springs ponds and the Mill-Willow bypass. Conversely, metals exceedances during runoff originate from scouring of tailings in the Clark Fork River floodplain, resuspension of metals-laden sediments from the streambed, and from the bypassing of Silver Bow Creek into the Mill-Willow channel.

(5) The reason for the high metals concentrations in Pond-2 discharge water during winter is not clearly understood. Possible explanations include reduced settling capacity due to winter ice cover, difficulties in liming during the winter, development of reducing conditions in the ponds that result in the release of metals from the sediments, or the discharge of phytoplankton which contain elevated metals concentrations. Elevated copper concentrations in the Mill-Willow bypass during winter are also difficult to explain.

(6) The two major tributaries of the upper Clark Fork, Rock Creek and the Little Blackfoot River, are low in metals and consequently are sources of good quality dilution water for the Clark Fork. This dilution is evidenced by the fact that metals concentrations are measurably lower immediately downstream from these tributaries.

(7) The reach of the Clark Fork downstream from the Little Blackfoot River that benefits from dilution during spring runoff is relatively short in length because of erosion by floodwaters of tailings deposits located downstream from the dilution source. For other than high flow periods, the benefits of dilution are realized for a greater distance downstream. This is particularly important from January until the onset of runoff.

(8) Reaches of the Clark Fork that have the most favorable conditions with respect to copper (below Warm Springs and Rock creeks) also have the highest fish populations. Reductions in tributary flow would decrease dilution and increase copper concentrations in the river.

(9) Median daily water temperatures exceeding the recommended criterion of 66°F have been recorded on numerous occasions during June, July and August at several locations between Deer Lodge and Clinton. Reductions in flow below those which presently exist will decrease water depth and velocity and will increase water temperatures.

(10) Dissolved oxygen concentrations less than the standard of 7.0 mg/l have been recorded during July and August. Further reductions in flow will put additional demands on the river to assimilate oxygen-consuming materials and thus cause lower oxygen concentrations.

g. Implications of Water Quality Flow Requests

January 1 through April 30

In the mainstem of the Clark Fork River, criteria for copper are routinely exceeded. A portion of the copper resulting in these exceedances originates upstream of Warm Springs Creek. This is particularly evident from January through April when copper leaving Pond-2 and in the Mill-Willow bypass causes copper concentrations to increase at stations many miles downstream.

Tributary inflow during this period is vital for dilution of copper and helps prevent more frequent and severe exceedances of copper criteria in the mainstem. All of the existing flow in the tributaries of the Clark Fork listed herein is necessary to maintain existing water quality in the Clark Fork during this period.

The above tributary flow is necessary until such time as the copper originating upstream from Warm Springs Creek from January 1 through April 30 is no longer of a magnitude to cause exceedances of the criteria for copper in downstream reaches.

May 1 through July 15

Spring high flows are desirable because they shape the stream channel through transport of sediment and bedload. However, the presence of toxic mine tailings in the streambanks and floodplain along the upper Clark Fork cause increased copper concentrations to occur during high flows. Consequently, it is not prudent to request a high spring flow during this period.

July 15 through September 30

During this period, water temperatures and dissolved oxygen concentrations can approach levels which are detrimental to aquatic life. Flow is one of several factors which influence both dissolved oxygen concentrations and temperature. Existing flow levels will prevent conditions from worsening.

October 1 through December 31

At this time of year irrigation water withdrawals are normally at a minimum. Current baseflow levels during this period will maintain water quality in its existing condition.

h. Water Quality Flow Requests

January 1 through April 30 - (1) All of the instantaneous streamflow, subject to existing, lawfully appropriated water rights, in the tributary streams shown in Table 11.

These flows should be reserved until such time as the copper concentrations originating upstream from Warm Springs Creek are no longer of a magnitude to cause exceedances in the criteria for copper in downstream reaches of the Clark Fork River.

May 1 through July 15, July 15 through September 30 and October 1 through December 31 - No additional flows are requested for water quality purposes during these periods.

Table 11. Summary of instream flow requests (cfs)

Stream/Reach	Year-round for Fish Habitat Jan. 1 - Dec. 31	Winter Low Flow Period for Water Quality Jan. 1 - April 30[1]
Clark Fork/#1	180	None
Clark Fork/#2	400	None
Clark Fork/#3	500	None
Clark Fork/#4	600	None
Warm Springs Cr/#1	50	All of the instantaneous base flow, subject to existing, lawfully appropriated water rights until such time as mine waste reclamation allows copper concentrations entering the Clark Fork above Warm Springs Creek to reach acceptable levels in downstream reaches.
Warm Springs Cr/#2	40	
Barker Creek	12	
Cable Creek	10	
Storm Lake Creek	10	
Twin Lakes Creek	13	
Lost Creek	16	
Little Blackfoot R/#1	17	
Little Blackfoot R/#2	85	
Snowshoe Creek	9	
Dog Creek	9	
Racetrack Cr/#1	26	
Racetrack Cr/#2	3	
Dempsey Creek	3.5	
Gold Creek	34	
Flint Cr/#1	50	
Flint Cr/#2	45	
Boulder Creek	20	
N. Fk Flint Creek	6	
Stuart Mill Creek	14	
Harvey Creek	3	

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[1] Flow is requested at each stream's confluence with the Clark Fork River.

7. Water Availability

Streamflow data for the upper Clark Fork River and certain tributaries were obtained from USGS gaging station records and through statistical techniques which reconstitute data where incomplete records exist. The statistical techniques used to reconstitute, or synthesize, data included the HEC-4 Monthly Streamflow Simulation Model developed by the Army Corps of Engineers, and other less complex methods. Addendum A contains the streamflow data analyzed in this section and includes a description of techniques used to reconstitute the data. A 32-year period of record (water years 1951-1982) was used for the analysis.

U. S. Geological Survey gaging stations on the mainstem Clark Fork are located at Deer Lodge, Gold Creek, Drummond, Clinton and above Missoula. Gaging stations on tributary streams are located on German Gulch, Racetrack Creek, Little Blackfoot River, Boulder Creek, Middle Fork of Rock Creek, Rock Creek and two locations on Flint Creek.

Portions of the upper Clark Fork River and the lower reaches of most of its tributaries are significantly depleted by agriculture and exhibit streamflow patterns which are characteristic of such depletion.

Streams that are not depleted by agricultural diversions typically have their lowest annual flows during winter. The hydrograph for the gage on Racetrack Creek, located upstream from all irrigation diversions, illustrates this characteristic (Figure 43). Although Racetrack Creek has a much lower discharge volume than does the mainstem Clark Fork, its hydrograph is representative of streams in western Montana with undepleted flows. The lowest flows occur during December, January and February. Never in the 32-year period of record did an August flow fall below the mean winter flow of 20.6 cfs. The lowest flow recorded for August was 34 cfs in 1973.

On streams that are heavily depleted due to summer irrigation withdrawals (such as the mainstem Clark Fork and the lower portions of most of its tributaries), the lowest yearly streamflows typically occur during August and September. Figure 44, a hydrograph for the Clark Fork at Gold Creek, illustrates this characteristic. Over the 32-year period of record the average August streamflow of the Clark Fork at Gold Creek was less than the average winter flow (446 cfs) for 29 out of 32 years. The lowest flow on record was 67.2 cfs in August of 1973.

A measure of the impact of current irrigation depletions on streamflows in the Clark Fork basin is provided by comparing the historic (with depletions) median monthly flows of the Clark Fork at Deer Lodge with the simulated median virgin (without depletions) flows[1/] for this site (Figure 45). It can be seen

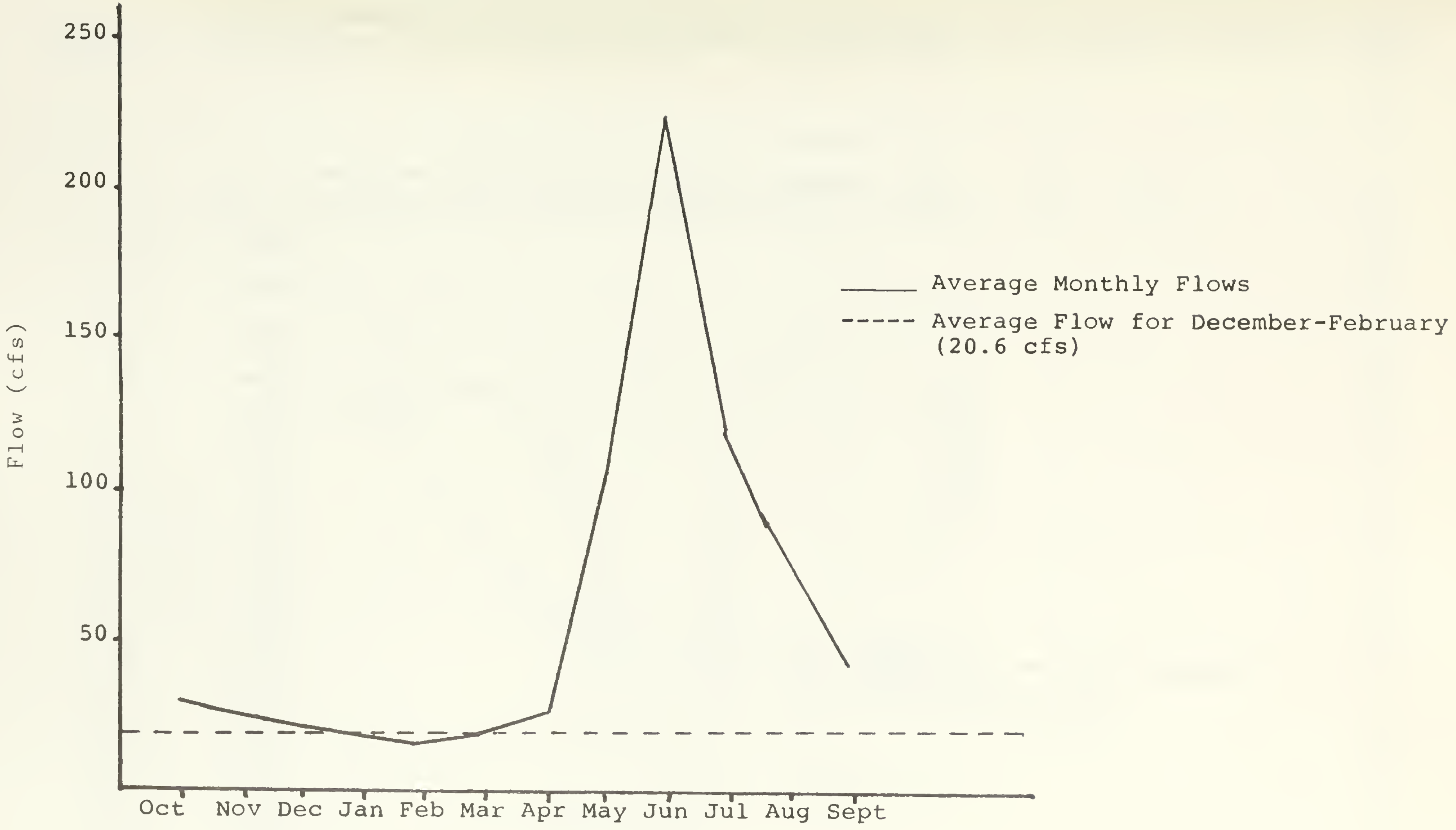


Figure 43. Streamflow of Racetrack Creek upstream from all irrigation diversions for a 32-year period of record (See Addendum A).

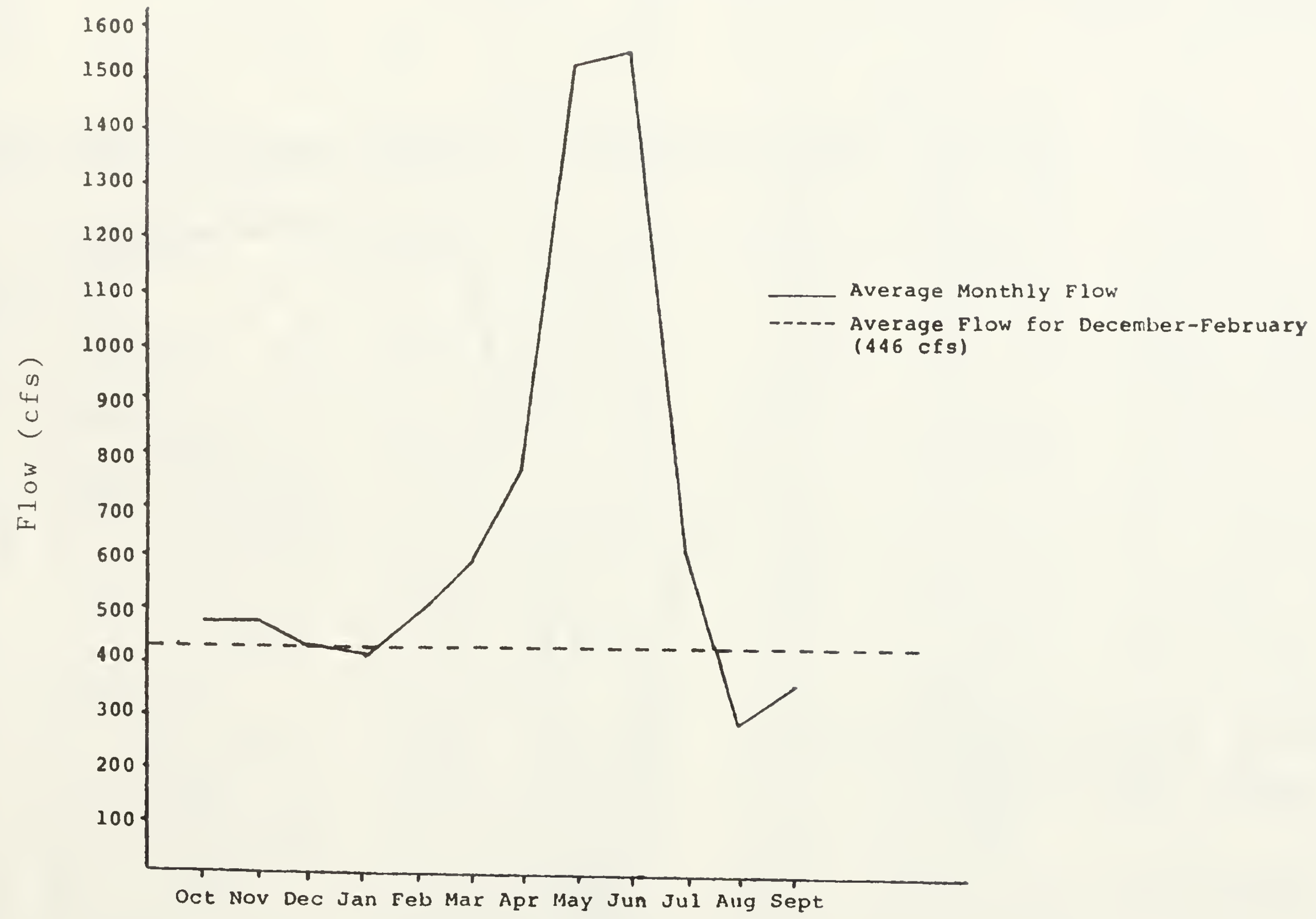
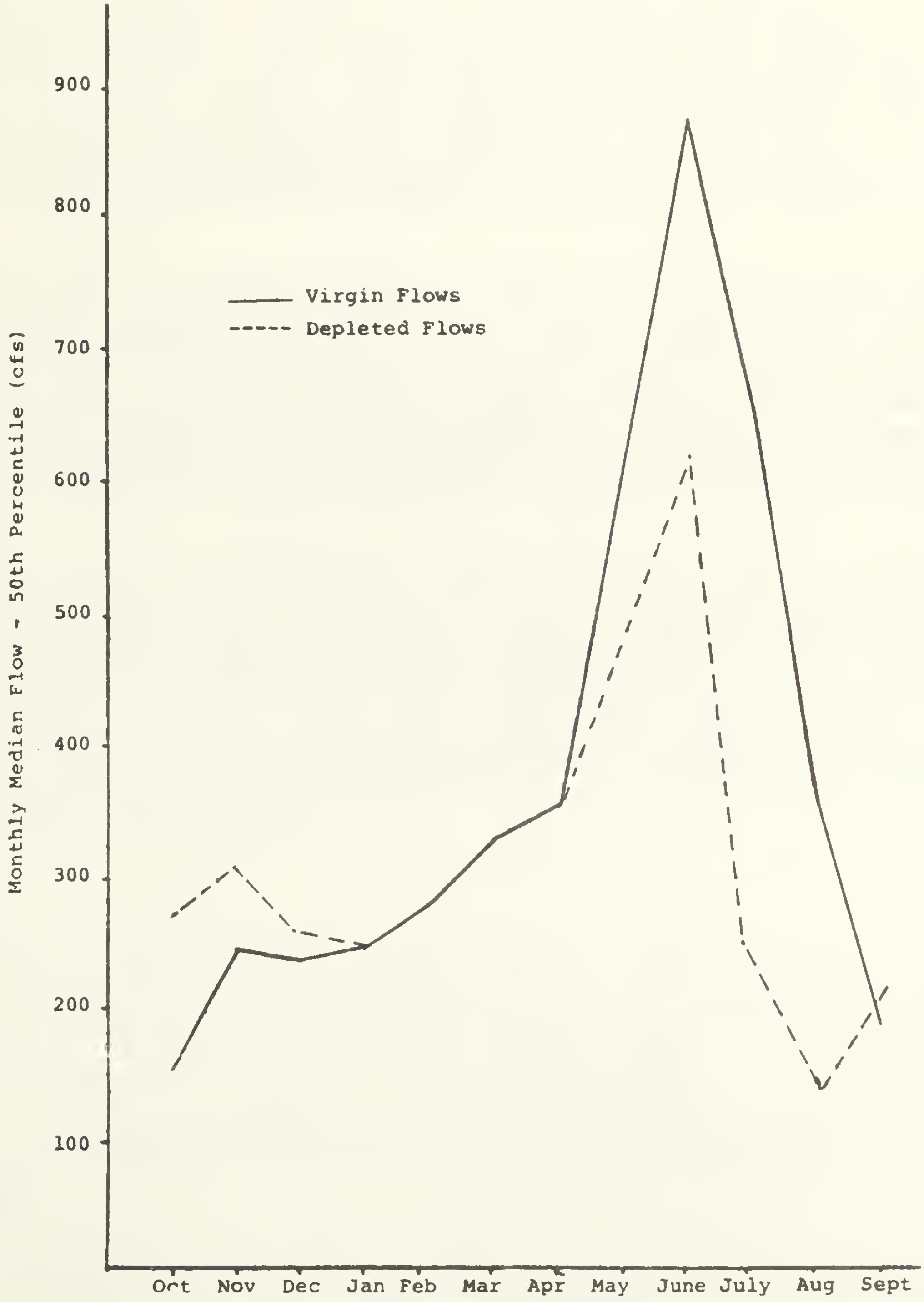


Figure 44. Streamflow of the Clark Fork river at Gold Creek for a 32-year period of record (See Addendum A).

Figure 45. Historic (depleted) and Simulated Virgin Flows in the Clark Fork River at Deer Lodge.



that the historic median flow in August (138 cfs) is well below the simulated median virgin flow (approximately 398 cfs). Assuming that the virgin flow hydrograph represents an overestimate of 25%, the historic median flow in August is still well below the simulated median virgin flow (300 cfs) for the same month.

The simulated median virgin flow for August (398 cfs) at Deer Lodge greatly exceeds the requested instream flow reservation of 180 cfs for this reach. However, due to the magnitude of existing irrigation depletions, the 180 cfs request exceeds the historic median flow for August (138 cfs). Yearly median August flows for the Clark Fork at Deer Lodge have been less than 180 cfs in 25 out of the last 32 years, illustrating the magnitude of present depletions.

An examination of flow records shows that during dry summer months water in the Clark Fork is in limited supply. These records were used to show the relationship between the requested instream flows and water availability. Excess water available when flows are at their 20, 40, 60 and 80th percentile exceedence levels[2/] was compared with instream flows providing high and low levels of aquatic habitat maintenance, as derived from the Wetted Perimeter Inflection Point Method (see Instream Flow Method section).

The 40th and 60th percentile flows encompass what could be considered normal flow conditions. As a general guideline for efficient full-service irrigation, a good water supply is usually considered to be necessary about 8 years out of 10, on the average (MDNRC 1976). The 80th percentile flow analysis is intended to evaluate that level of water availability, and represents a well below average water year. Conversely, the 20th percentile flow analysis evaluates water availability in a well above average water year.

[1/] Simulated virgin flows are derived by assuming that actual streamflow records reflect water diversions, consumption of water by crops, losses due to other causes and return flows through the groundwater. Errors in deriving virgin flows are inevitable because it is not feasible to accurately predict the land area being irrigated at a given time or the amount of water being applied. Although virgin streamflow hydrographs are not without some error, they are useful in interpreting characteristics of water use.

[2/] See Addendum D. A 20th percentile exceedence flow, for example, is that flow which would be exceeded only 2 years out of 10. Similarily, an 80th percentile exceedence flow would be exceeded 8 years out of 10.

During some months at several locations, flows are already below those requested for protection of fish habitat (Tables 12-15). Upstream reaches of the Clark Fork will have less water available in excess of the requested flow reservation than will lower reaches. At a 20th percentile exceedance flow, for example, there would be no water available during August in excess of high maintenance values (400 and 500 cfs) at Garrison, Gold Creek and Drummond (Table 12). At an 80th percentile exceedance flow, no water would be available in excess of the low maintenance values (90 and 200 cfs) during August at Deer Lodge, Garrison and Gold Creek. With reservations at the high maintenance levels (180, 400 and 500 cfs), no water would be available in excess of the reservation at an 80th percentile exceedance flow during July, August and September at Deer Lodge, Garrison, Gold Creek, Drummond and Clinton.

These data show that during the high demand summer low flow period there would be little or no water available in excess of the reservation in the upper reaches (Reaches 1 through 3) even during relatively high flow years. The lack of water in excess of that reserved for instream flows would limit additional expansion of irrigated agriculture in the upper reaches of the river to water made available through water conservation measures or from storage. Even without an instream reservation, water available for new consumptive use during July, August and September of low flow years is very limited.

It is clear from the historic and reconstituted streamflow data that existing demands for water often deplete summer flows in the Clark Fork and certain tributaries to levels which are inadequate to maintain the ecological integrity of aquatic ecosystems. During the summer of 1985, for example, low spring and summer rainfall, coupled with low runoff from snowmelt, created drought conditions in western Montana. Diversions of water for irrigation in 1985 dewatered five miles of Warm Springs Creek. Stream gage records at Warm Springs show that flows averaged less than 0.3 cfs for most of July, with the lowest flow of .06 cfs being recorded on July 9, 1985. Figure 46 is a streamflow hydrograph of Warm Springs Creek showing the extreme dewatered condition during July and August of 1985.

Similar dewatered conditions occurred on the mainstem Clark Fork approximately five miles upstream from Deer Lodge. At this point, the USGS measured the flow downstream from an irrigation diversion on August 8, 1985 at 5.6 cfs. (On August 20, 1986 at the same site, the USGS measured the flow at only 2.71 cfs, less than half that measured in 1985.) Figure 47 is a hydrograph of the Clark Fork at Deer Lodge for the 1985 water year. The depleted flows in July and August were well below 90 cfs - the flow providing a low level of aquatic habitat maintenance.

Table 12. Water available in excess of two instream flow levels at a 20th percentile exceedance flow for reaches of the mainstem Clark Fork River.

Reach	Location	Instream Flow (cfs)*	Excess Water Available (cfs) July	August	September
1	Deer Lodge	90	339	91	208
		180	249	1.2	118
2	Garrison	200	424	47	179
		400	223	0	0
2	Gold Creek	200	729	154	281
		400	529	0	81
3	Drummond	180	949	262	530
		500	629	0	210
3	Clinton	180	1175	354	594
		500	855	34	274
4	Turah	300	2088	678	814
		600	1788	378	514

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*The lower instream flow shown at each location is the flow necessary to maintain the low level of aquatic habitat potential, while the higher flow is the flow necessary to maintain the high level of aquatic habitat potential (see Instream Flow Method section. The higher flows are the ones requested in this application.

Table 13. Water available in excess of two instream flow levels at a 40th percentile exceedance flow for reaches of the mainstem Clark Fork River.

Reach	Location	Instream Flow[*] (cfs)	Excess Water Available (cfs) July	August	September
1	Deer Lodge	90	225	51	150
		180	135	0	60
2	Garrison	200	294	4	98
		400	94	0	0
2	Gold Creek	200	225	84	189
		400	256	0	0
3	Drummond	180	650	175	392
		500	330	0	72
3	Clinton	180	882	243	428
		500	562	0	108
4	Turah	300	1582	505	590
		600	1282	205	290

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[*] The lower instream flow shown at each location is the flow necessary to maintain the low level of aquatic habitat potential, while the higher flow is the flow necessary to maintain the high level of aquatic habitat potential (see Instream Flow Method section). The higher flows are the ones requested in this application.

Table 14. Water available in excess of two instream flow levels at a 60th percentile exceedance flow for reaches of the mainstem Clark Fork River.

Reach	Location	Instream* Flow (cfs)	Excess Water Available (cfs) July	August	September
1	Deer Lodge	90	114	34	98
		180	24	0	8
2	Garrison	200	127	0	47
		400	0	0	0
2	Gold Creek	200	225	57	104
		400	25	0	0
3	Drummond	180	358	123	267
		500	38	0	0
3	Clinton	180	411	177	312
		500	91	0	0
4	Turah	300	1127	430	454
		600	827	130	154

*The lower instream flow shown at each location is the flow necessary to maintain the low level of aquatic habitat potential, while the higher flow is the flow necessary to maintain the high level of aquatic habitat potential (see Instream Flow Method section). The higher flows are the ones requested in this application.

Table 15. Water available in excess of two instream flow levels at an 80th percentile exceedance flow for reaches of the mainstem Clark Fork River.

Reach	Location	Instream Flow (cfs)[*]	Excess Water Available (cfs)		
			July	August	September
1	Deer Lodge	90	21	0	56
		180	0	0	0
2	Garrison	200	0	0	6
		400	0	0	0
2	Gold Creek	200	39	0	36
		400	0	0	0
3	Drummond	180	115	32	205
		500	0	0	0
3	Clinton	180	239	103	275
		500	0	0	0
4	Turah	300	636	326	394
		600	336	26	94

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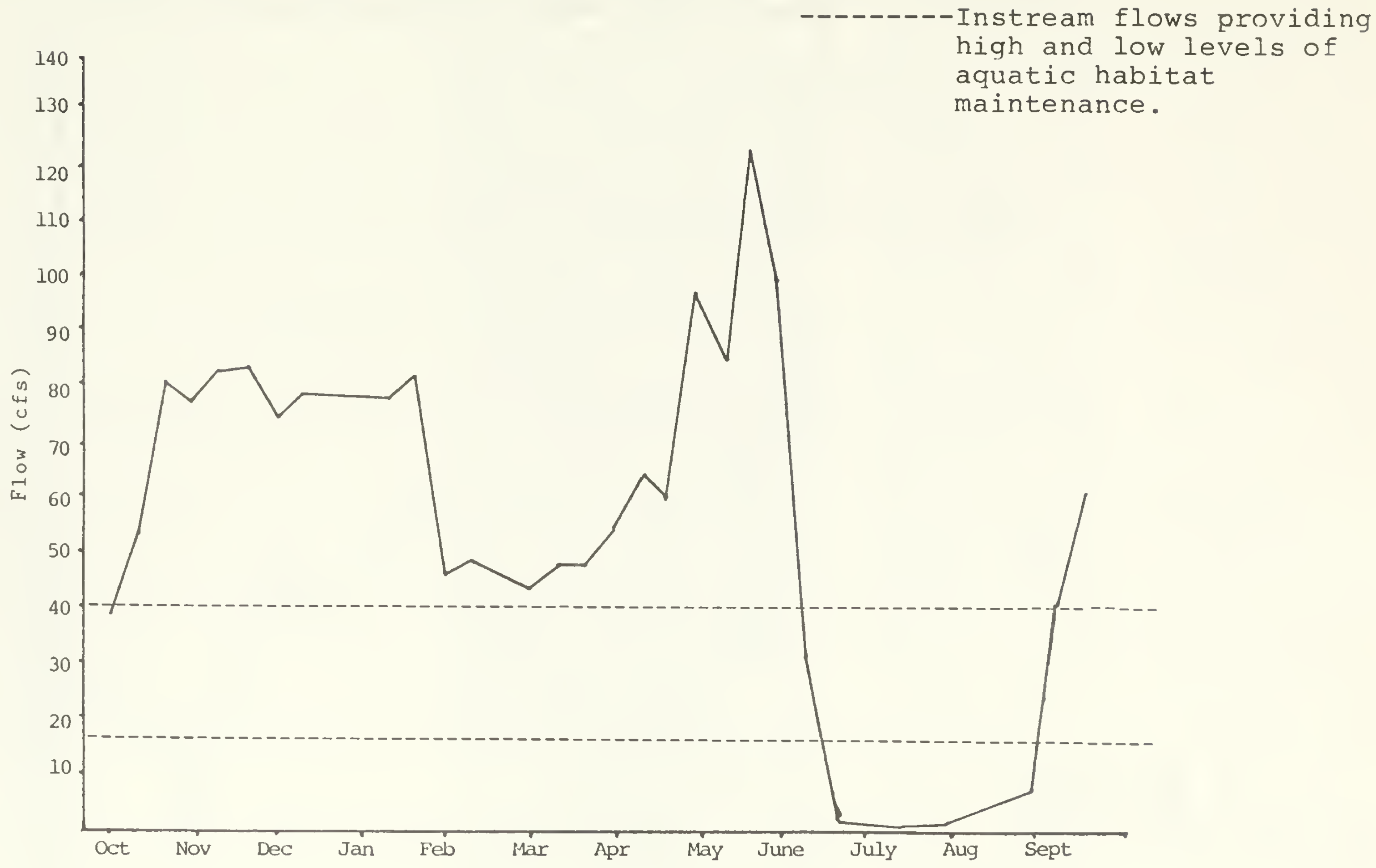
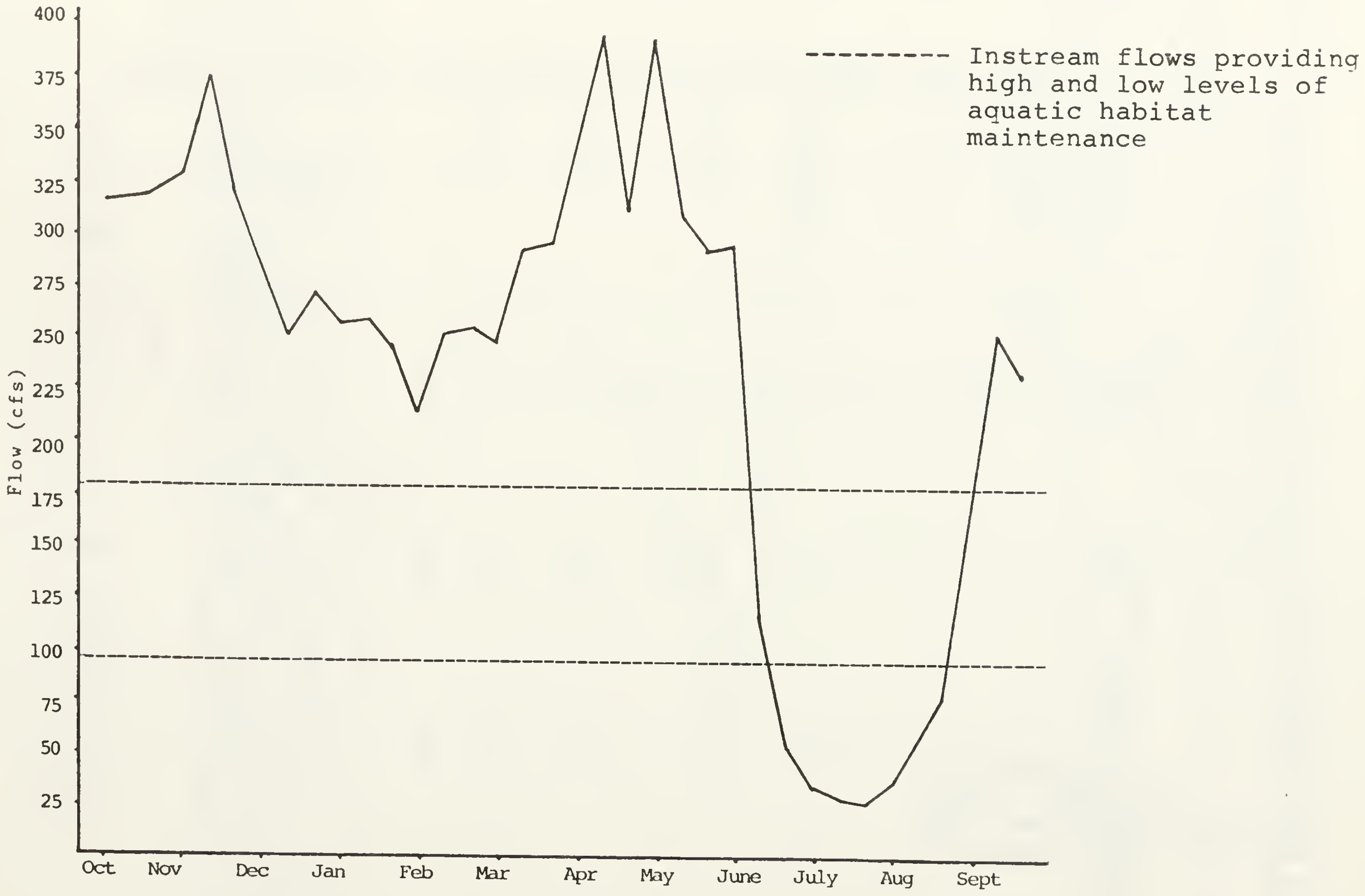
[*] The lower instream flow shown at each location is the flow necessary to maintain the low level of aquatic habitat potential, while the higher flow is the flow necessary to maintain the high level of aquatic habitat potential (see Instream Flow Method section). The higher flows are the ones requested in this application.

Figure 46. Streamflows of Warm Springs Creek, 1985 Water Year.



Source: U.S. Geological Survey, Water Resources Division.

Figure 47. Streamflows of the Clark Fork River at Deer Lodge, 1985 Water Year.



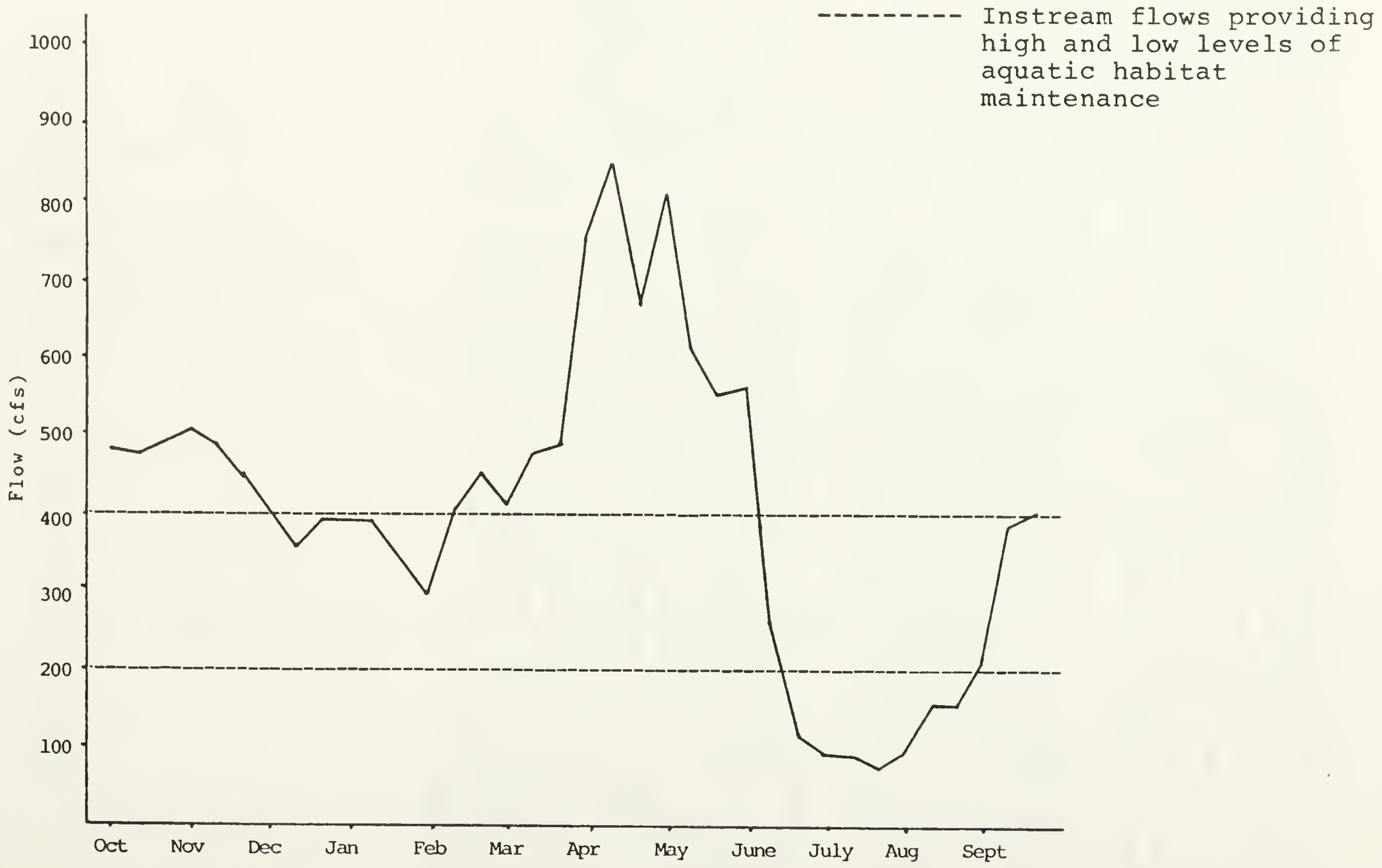
Source: U.S. Geological Survey, Water Resources Division.

Figures 48 and 49 are hydrographs of the Clark Fork River at Gold Creek and near Clinton, respectively. These stream reaches both had severely depleted flows in July and August, 1985. The flow of the Clark Fork near Clinton, however, was less than 180 cfs (the instream flow required to provide the low level of aquatic habitat maintenance) for a two-week period, whereas the upper reaches of the Clark Fork were depleted to less than the low maintenance flow for four to six weeks during the summer.

The hydrograph for the Little Blackfoot River (Figure 50) shows that the river was not as severly dewatered during July and August, 1985 as the Clark Fork or Warm Springs Creek. Because the gage on the Little Blackfoot is located downstream from most irrigation diversions, the hydrograph reflects return flows from irrigation. The relatively inefficient conveyance and flood irrigation systems along the Little Blackfoot and permeable flood plain soils are factors which may contribute to the relatively high return flows in the Little Blackfoot River drainage.

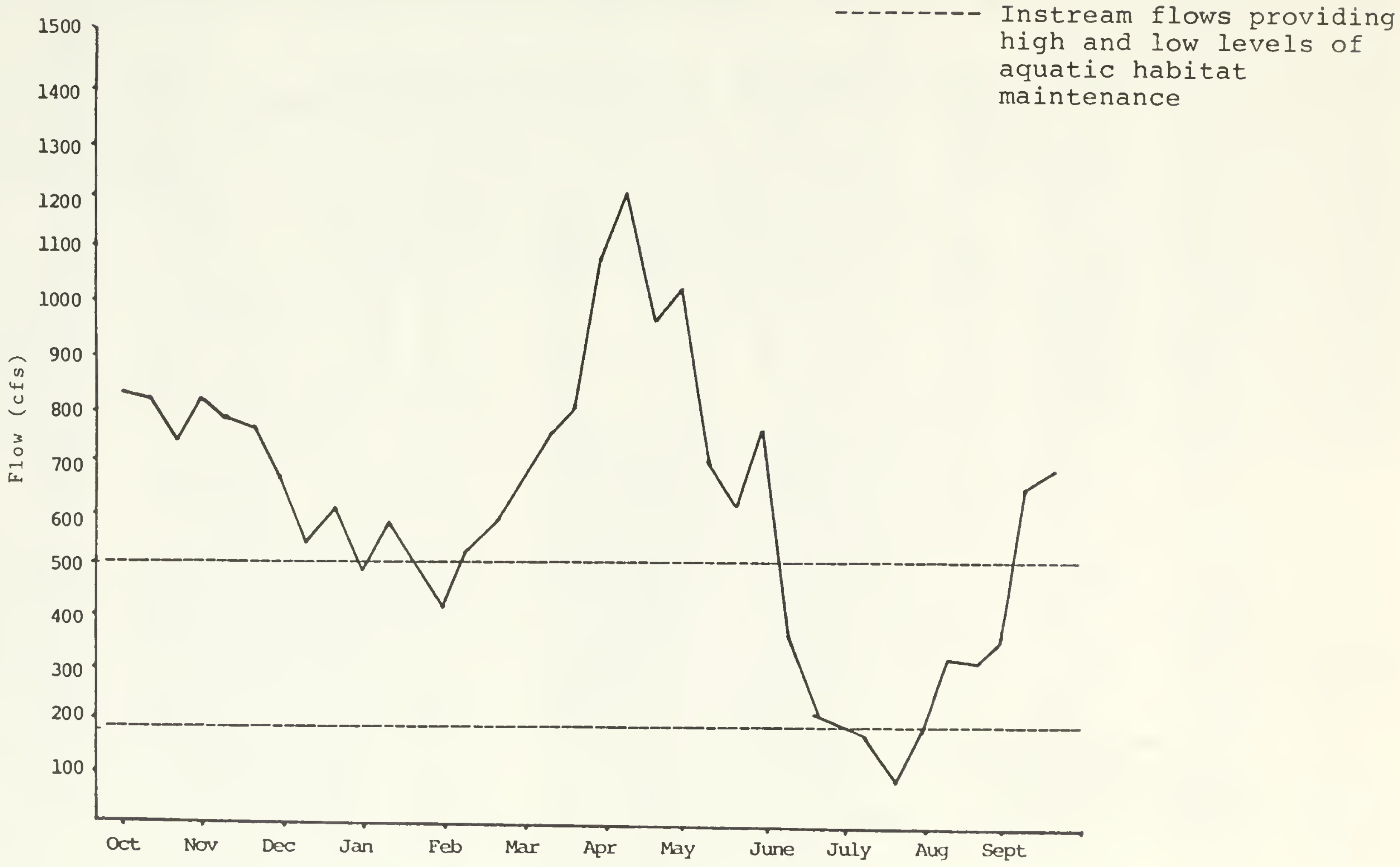
It is apparent that, in seriously dewatered portions of the mainstem Clark Fork, sufficient water is not available to routinely meet instream flow requirements for the high level of aquatic habitat potential. Since existing rights are not affected, an instream flow reservation will not improve the water availability situation. It will, however, establish a level below which new consumptive users should not further deplete the river. This will not only prevent the existing dewatering from becoming more frequent or more severe, but it will also maintain the potential for enhancing the existing fish populations if water can be made available through the purchase of existing water rights, the construction of new water storage facilities, or the rehabilitation and improved management of existing facilities.

Figure 48. Streamflows of the Clark Fork River at Gold Creek, 1985 Water Year.



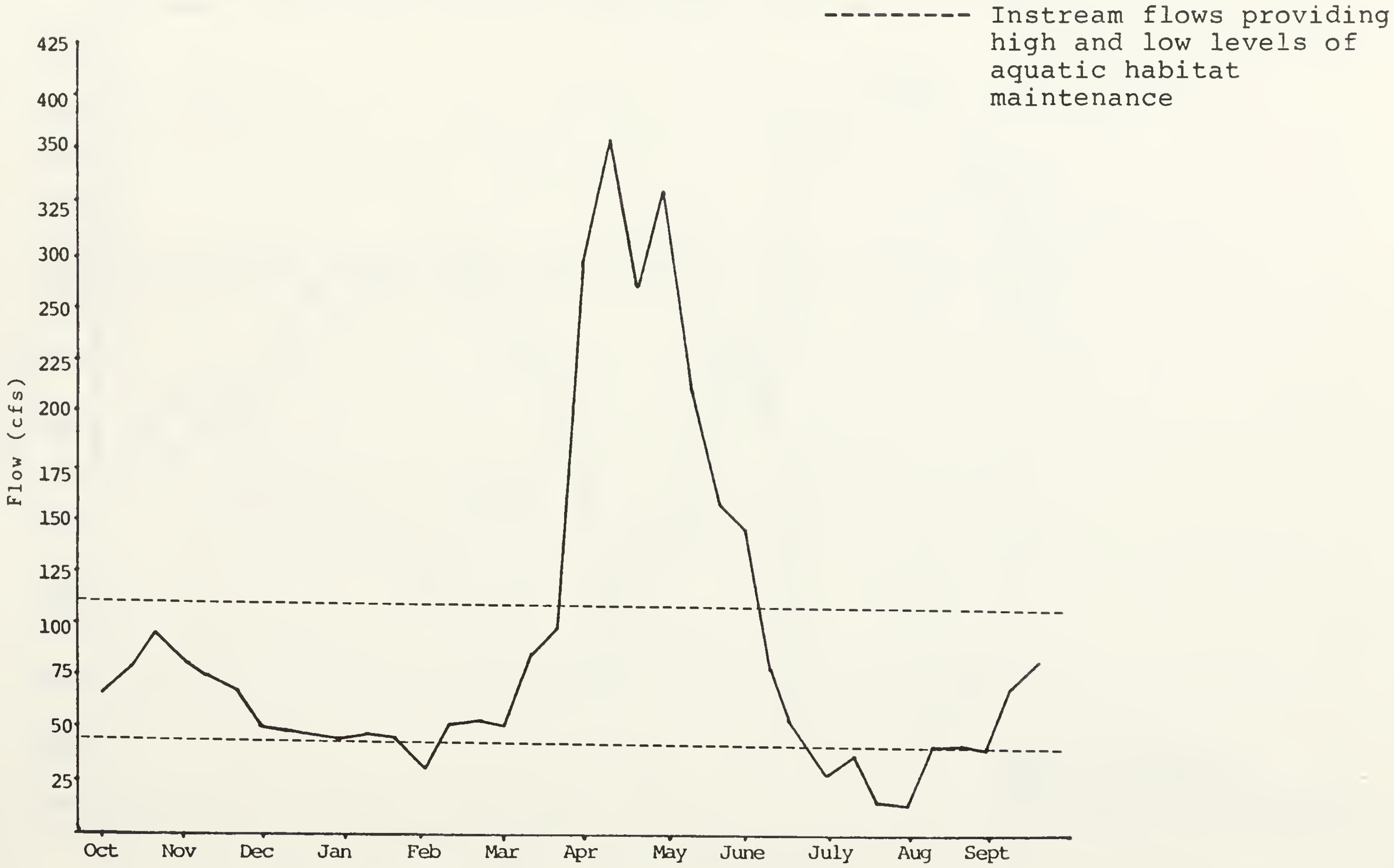
Source: U.S. Geological Survey, Water Resources Division.

Figure 49. Streamflows of the Clark Fork River near Clinton, 1985 Water Year.



Source: U.S. Geological Survey, Water Resources Division.

Figure 50. Streamflows of Little Blackfoot River near Garrison, 1985 Water Year.



Source: U.S. Geological Survey, Water Resources Division.

D. STATEMENT THAT THE RESERVATION IS IN THE PUBLIC INTEREST

1. Introduction

The reservation for instream flows in the upper Clark Fork River and selected tributaries is clearly in the public interest. The public benefits which will occur from the reservation include the following:

(1) continued perpetuation of the fish and wildlife resources as currently found in the Upper Clark Fork basin, whose very existence is in the public interest;

(2) continued perpetuation of the fish and wildlife resources found in the upper Clark Fork basin for current and future utilization by the public;

(3) preservation of sufficient streamflow to allow future enhancement of fish populations in those reaches of the Clark Fork River currently degraded by water quality problems, and to maximize the benefits from the expenditures required to clean up the upper Clark Fork environment;

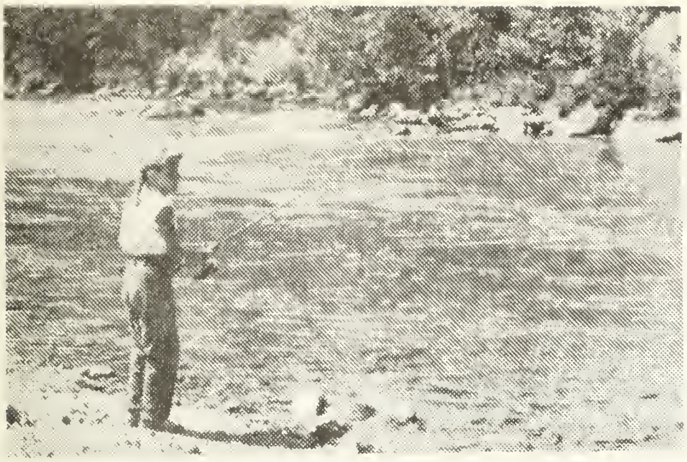
(4) prevention of the further depletion of streamflows currently enjoyed by the public for recreational uses;

(5) maintenance of, and potential improvement in, water quality which contributes to a clean, healthful environment for the citizens of Montana and the nation; and

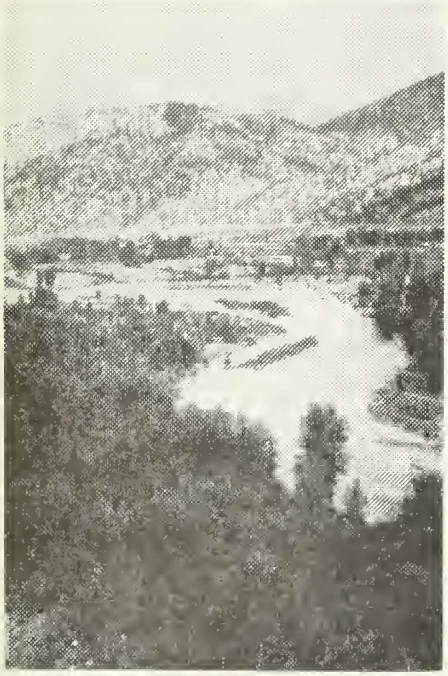
(6) contribution to the protection and continued utilization of existing water rights in the basin.

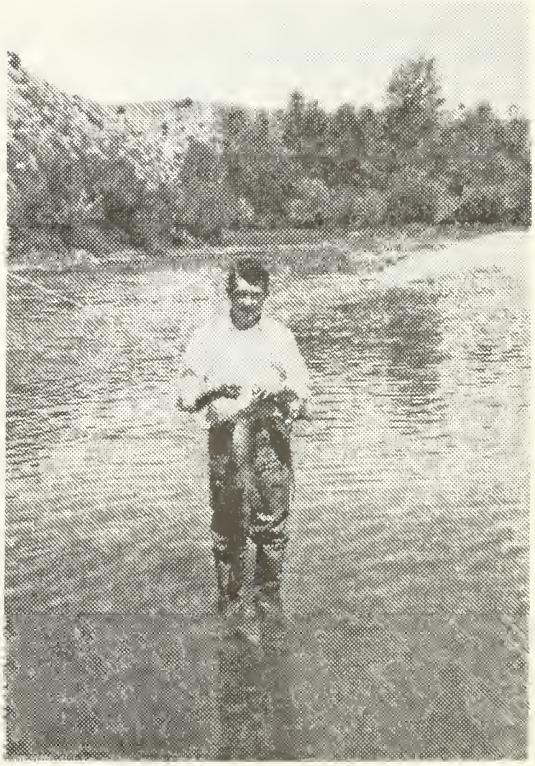
This application is a request for establishment of an instream flow level in the upper Clark Fork River and selected tributaries for maintenance of the related fisheries, wildlife and recreational resources, and to prevent a further deterioration in the quality of water. Establishment of a minimum instream flow would not, in any way, affect the validity or utilization of any water rights in existence at the time an instream flow reservation is granted. Existing water rights would, to some extent, be protected from conflict with future water use by the instream reservation.

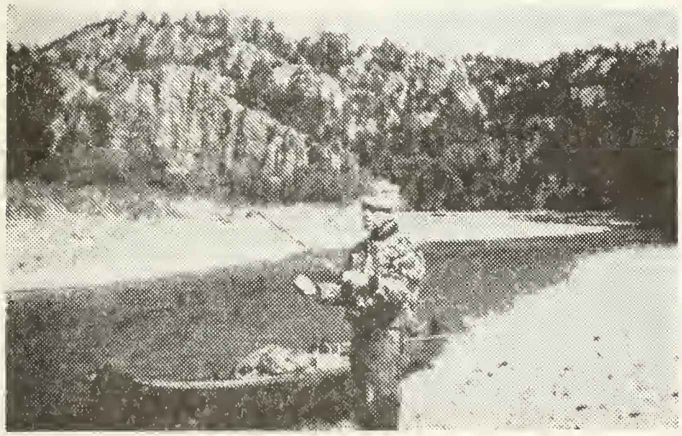
An instream flow reservation would, at times, limit the availability of water for future consumptive use. Water would be available for future consumptive use only when flows are in excess of the minimum instream flow reservation. An instream flow reservation would not guarantee that a minimum flow would always be present in the stream. It would, however, ensure that future depletions would not cause low flow events to occur more frequently, or be more severe, than they have been in the past.



STATEMENT THAT THE RESERVATION IS IN THE PUBLIC INTEREST







The reservation would promote the maintenance of fish populations at current, existing levels, provide the opportunity for enhancement of fish populations in the future when water pollution problems are lessened, and contribute to the protection and continued utilization of existing water rights in the basin--all public benefits.

Fish and wildlife have always been a part of the Montana lifestyle. For many centuries they have been a source of support for human life and continue to be a part of the way of life in Montana. They have been, and are, a continual source of public recreation. The public recreation supported by the Clark Fork River and its major tributaries provides economic opportunities for towns and cities in the basin.

A discussion of the adverse and beneficial environmental and economic effects of the reservation are required in the Montana Administrative Code rules and rules adopted by the Board of Natural Resources and Conservation for establishment of water reservations. Major interests in the upper Clark Fork basin potentially affected by an instream flow reservation include fish, wildlife, recreation, agriculture, municipalities and industry. The effect of granting the requested instream flow reservation on these interests is discussed in the following sections.

2. Agriculture

a. Existing Situation

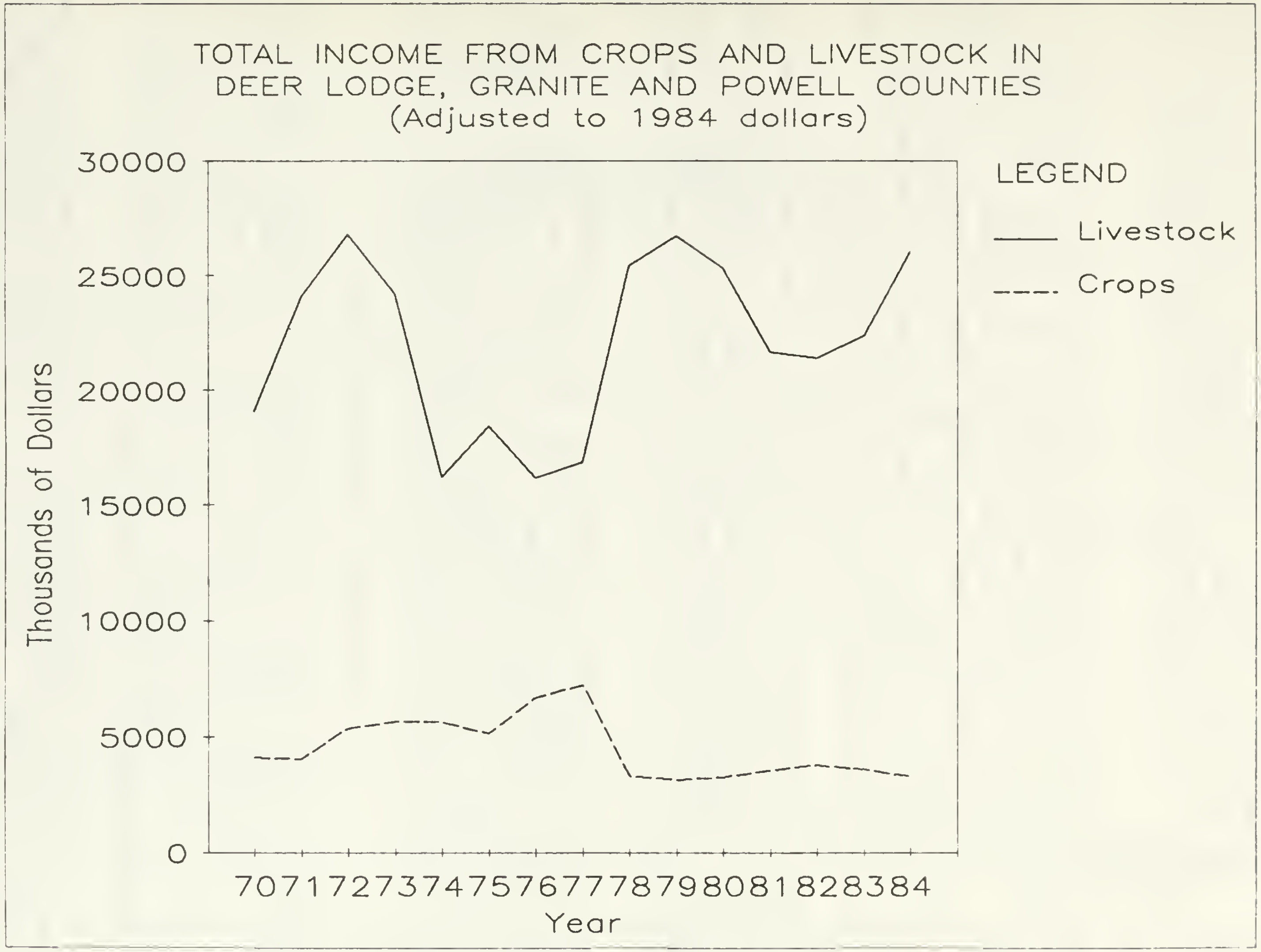
The agricultural base in the upper Clark Fork basin is primarily dependent upon livestock production. Over a 16-year period (1970 through 1985), livestock contributed approximately 84% of the total agricultural revenue in the three counties (Deer Lodge, Granite, and Powell) comprising most of the upper Clark Fork basin (see Figure 51 and Addenda E-1 and E-2 for yearly cash revenues contributed by livestock and crops in the three counties).

Agriculture in the upper Clark Fork basin is livestock-oriented; therefore, much of the crop production (both irrigated and non-irrigated) is utilized for winter and spring livestock feeding. Hay and alfalfa are the primary crops, with small grains commonly being harvested for livestock forage.

b. Irrigated Lands

Based on water resources data tabulated by the Montana Department of Natural Resources and Conservation (DNRC) and through field investigation, it is estimated that approximately 82,000 acres have been developed for irrigated agriculture in the upper Clark Fork basin. Although the acreage of land irrigated varies from year-to-year, an average of 86% of the cropland in Deer Lodge, Granite and Powell counties has been irrigated over the last 16

Figure 51



SOURCES: Regional Economic Measurement Division, Bureau of Economic Analysis, Department of Commerce, Washington, D.C.
"Business Statistics" (1979, 1982), Bureau of Economic Analysis, Department of Commerce. Washington, D.C.

years. The highest levels of irrigated crop production occurred between 1973 and 1976, and declined to a low in 1977 through 1979. The yearly trend since 1979 indicates that the total acreage of irrigated crops harvested has varied, but the trend has been generally upward (Figure 52). However, between 1970-1985 the net gain or loss of irrigated acreage appears to be close to zero, if not slightly downward (See Addendum G for a yearly summary of Irrigated and non-irrigated cropland, in the three counties).

The irrigated lands in the upper Clark Fork basin generally lie on the floodplains of the drainages or on river terraces and benches above the floodplains. Irrigation water is primarily delivered through open ditches that originate at higher elevations on tributary streams where the steams emerge from steep mountainous terrain. The water is applied through sprinkler systems or through flood irrigation networks. Few irrigators pump water directly from the Clark Fork or its major tributaries to the benches adjacent to the floodplain.

Transportation corridors (e.g., railroads, interstate highway and roads) closely parallel the Clark Fork River and major tributaries throughout the basin. Cost considerations and construction problems associated with traversing these corridors probably restrict irrigation access through considerable portions of the basin.

According to information provided by Morrison-Maierle, Inc., a Helena engineering firm, it cost $250 per foot in 1984 to bore a hole under the interstate highway and railroad at Deer Lodge and jack a 12-inch pipe through the hole. To traverse both the highway and the railroad required approximately 75 feet of boring. In 1984 dollars, traversing the transportation corridors added approximately $18,750 to project costs (Elliott 1986).

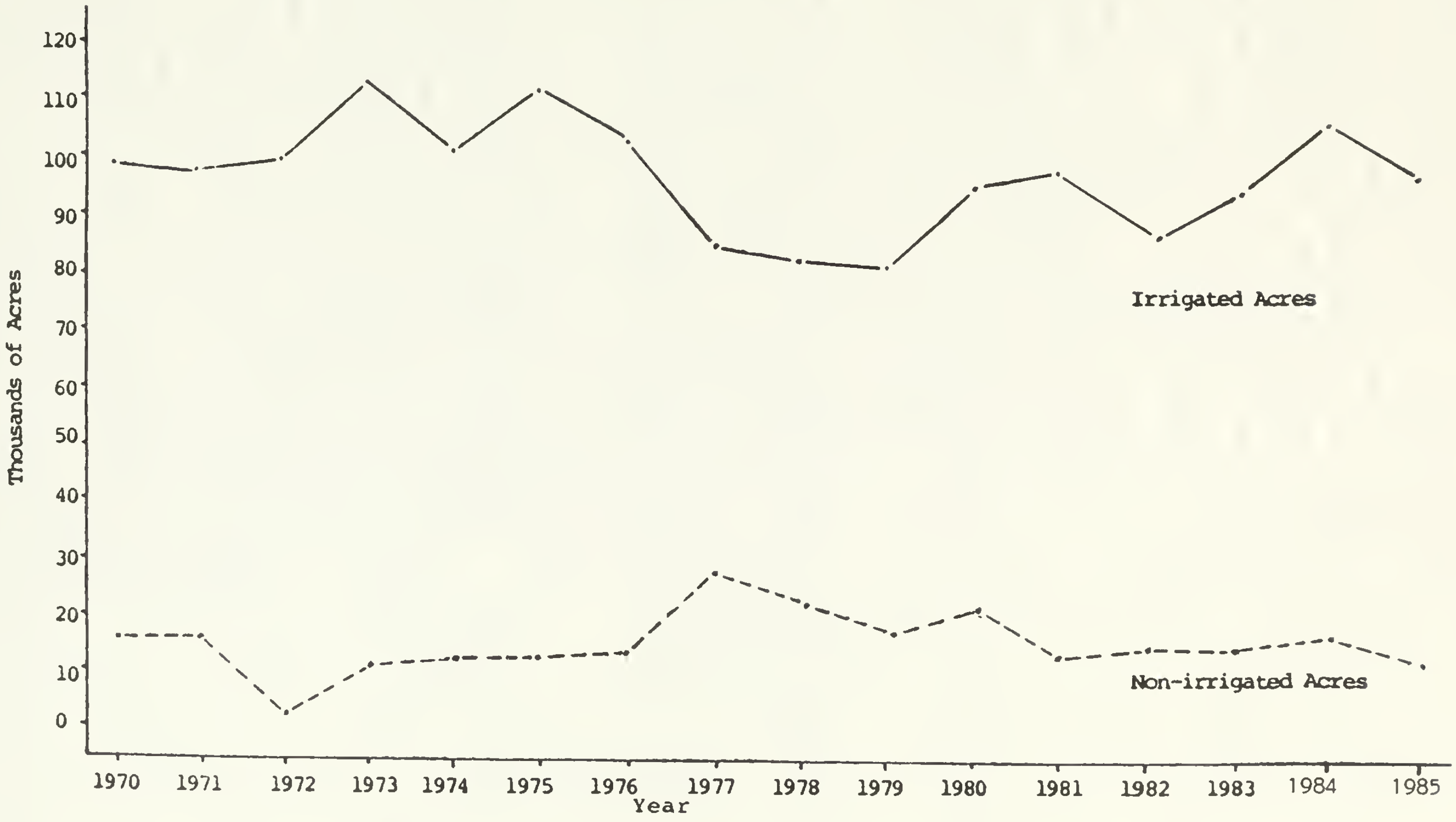
c. Potentially Irrigable Lands

Approximately 7,842 acres of potentially irrigable lands have been identified and mapped in the upper Clark Fork basin along the major drainages (See Addendum B for an analysis of this inventory). Most of these lands are more than 1/2 mile and 100 to 150 feet in elevation from the Clark Fork River or a major tributary (i.e., Flint Creek or the Little Blackfoot River) and lie on benches adjacent to floodplains.

Additional acreages of potentially irrigable lands have been identified along tributaries of the Little Blackfoot River (5,765 acres) and Flint Creek (3,477 acres). However, due to the lack of streamflow data on the tributaries of the Little Blackfoot and Flint Creek, it is not known if sufficient streamflows exist to provide full service irrigation to the potentially irrigable acreages.

Figure 52

IRRIGATED AND NON-IRRIGATED LAND IN
DEER LODGE, GRANITE, AND POWELL COUNTIES



SOURCE: Montana Crop and Livestock Reporting Service.

Field reconnaissance of the upper Clark Fork basin did not reveal any irrigation projects where water is being pumped more than 1/2 mile and higher than 100 feet in elevation from the water source. The apparent absence of irrigation projects in the upper Clark Fork basin which pump water more than 1/2 mile from the Clark Fork or major tributaries, although such projects appear to be economically feasible, may be due to factors such as: (1) a depressed agricultural economy, (2) insufficient water rights, (3) inadequate seasonal water supply, (4) constraints imposed by transportation corridors, (5) lack of capital to invest in such projects and (6) land ownership conflicts.

The largest blocks of potentially irrigable land in the basin lie on the east side of the Clark Fork River between Deer Lodge and Garrison, and southeast of the confluence of Flint Creek and the Clark Fork. Because there are economies of scale associated with larger projects, it is probable that the larger blocks of land would have the greatest potential for irrigation development.

d. Benefits

The instream flows requested in this application will contribute to the protection and continued utilization of existing water rights in the upper Clark Fork basin. Existing water rights in the basin will at all times be honored. Section 85-2-316, subsection (8) states: "A reservation under this section shall date from the date the order reserving water is adopted by the board and shall not adversely affect any rights in existence at that time."

The majority of the water rights in the upper Clark Fork basin are agricultural. To effectively exercise an existing water right, streamflow must be sufficient to supply the right and allow for the functioning of the diversion structure. Portions of the upper Clark Fork and the lower reaches of several of its major tributaries are already significantly affected by dewatering. It is the responsibility of the holder of a water right to protect the integrity of that right against encroachment by junior appropriators. This inevitably leads to conflict in highly appropriated basins during low flow years.

An instream flow reservation can provide a buffer between existing water users and whatever future water use may occur. It can contribute to the protection and continued utilization of existing water rights by relieving some of the burden of the existing water right holder. By limiting future water depletions during low flow conditions, an instream flow reservation would prevent low flow events from becoming more frequent and more severe. This would benefit existing water users in the upper Clark Fork basin. An instream flow reservation will also help ensure that the existing quality of irrigation water will not be reduced. This will be a benefit to crop production.

e. Impacts

As stated in the previous section, reservation of instream flows in the upper Clark Fork drainage will have no adverse impacts on existing irrigated agriculture. Instream flow reservations may, however, have impacts on the expansion of irrigated agriculture. The magnitude of possible impacts would depend upon the probability that there would be a demand to bring new lands under irrigation. Based on soil and economic criteria, it appears that there are approximately 17,084 acres of potentially irrigable land within the upper Clark Fork basin. However, it is not possible to predict whether these lands would actually be irrigated given the possible constraints of land ownership, water availability and lack of investment capital.

Under a worst-case scenario, approximately 17,084 acres of new land could be eliminated from future irrigation. Because peak demands for irrigation water usually coincide with low summer stream flows, conflicts between increased irrigation demands and minimum instream flows would be inevitable. These conflicts would occur first on those portions of the mainstem and lower reaches of tributaries which are already significantly dewatered.

If it is assumed that a more realistic, less-than-worst-case situation would exist, there would be considerably less potentially irrigable land affected by the reservation. Because most of the potentially irrigable lands lie at the margin of economic feasibility, the risks associated with developing irrigation on these lands are relatively high. In order to justify development costs, consistently high crop yields must be realized and crop prices must remain favorable over a relatively long payback period. To ensure maximum crop production, consistent and optimum quantities of irrigation water must be available and the level of water management must be high. Increases in electric rates, decreases in crop prices, dry years, and inefficient water management could act singly or in concert to render marginal irrigation projects economic liabilities. It is probably because of the economic risks associated with marginal irrigation projects that there are apparently no existing projects which pump water to the irrigable lands more than 1/2 mile from the water source. The following statement by the Cooperative Extension Service (1980) may realistically reflect the future for expanded irrigation in the upper Clark Fork basin:

> "The future growth of irrigation will not be spectacular. There will probably be an emphasis on better use of water on lands presently irrigated through better management of surface irrigation systems or in some case conversion to sprinklers."

Impacts of instream flow reservations on potentially irrigable land could be lessened by improving irrigation efficiency, constructing reservoirs or by pumping groundwater. By increasing irrigation water through these measures, service to existing irrigation systems could be improved and/or the irrigated land base could be increased.

Although such mitigation measures are technologically feasible, the costs may be prohibitive unless subsidized. Currently, the Water Development Bureau of the DNRC provides 25% funding and low interest loans for water development and irrigation projects that do not exceed $200,000. The Soil Conservation Service (SCS), under Public Law 566, can provide 50% funding for flood control water development projects. It is possible that individual farmers and ranchers could receive financial aid from the DNRC to increase amounts of irrigation water and to improve efficiency of irrigation water delivery and application, thereby allowing for an expansion of the irrigated land base even with instream flow reservations.

Expansion of irrigated agriculture and future efforts to augment stream flows in the upper Clark Fork basin may require water storage projects. Such projects are not precluded by this application because a large instream flow reservation for the spring high flow period is not requested.

3. Industry

a. Existing Situation

Industry in the upper Clark Fork basin has historically been dominated by mining and processing of mined products. In recent years, however, the closure of the AMC Butte and Anaconda operations have greatly reduced mining and mining-related activities within the basin and, consequently, the demand for industrial water. Currently the largest industries in the basin are Stauffer Chemical Company, located between Butte and Anaconda, and Montana Resources, Inc. located in Butte. The latter recently aquired and began limited mining activities at the former AMC properties in Butte.

At least 40 facilities are permitted to discharge treated wastewater in the Clark Fork River Basin (Table 16). Twelve (12) of these facilities discharge treated wastewater to streams for which the Department of Fish, Wildlife and Parks has applied for reserved flows, or they discharge into streams (or stream reaches) which will be influenced by the flow reservation.

Permits written for existing discharges are designed to prevent exceedence of numerical water quality standards (for coliform bacteria, dissolved oxygen, pH, temperature, turbidity, and color) down to the 7-day, 10-year low flow of the receiving water. For variables that do not have numerical standards (sediment, nutrients, toxics, and other deleterious substances), no increases are allowed above naturally occurring concentrations which would create a nuisance or render the receiving water harmful, detrimental or injurious to beneficial uses.

Table 16.

Expiration Date

MONTANA WASTEWATER DISCHARGE PERMITS IN THE CLARK FORK RIVER BASIN[1/]

Permittee's Name	Expiration Date
+Town of Thompson Falls	12-31-82
Town of Darby	03-01-88
+Town of Drummond	03-01-88
+Town of Superior	04-30-83
+Montana Warm Springs State Hospital	03-01-88
+Town of Philipsburg	03-01-88
+Town of Alberton	07-31-83
Town of Stevensville	07-31-83
Western Materials, Inc.	01-31-84
*University of Montana - Yellow Bay	04-30-84
Charlo Sewer District	06-30-84
*Flathead County Commissioners - Big Fork	06-30-84
Montana Power Company - Kerr Dam	06-30-84
*Hungry Horse Dam	06-30-84
Stevensville Water Treatment Plant	07-31-84
*Town of Whitefish	08-31-84
Town of Hot Springs	12-31-84
+Montana Galen State Hospital	01-31-85
*City of Columbia Falls	04-30-85
Mountain Water Company	05-31-85
+J.R. Daily	10-31-85
Montana Fish & Game - Jocko Hatchery	04-30-86
+Montana Fish & Game - Washoe Hatchery	04-30-86
*Montana Fish & Game - Flathead Hatchery	04-30-86
*Burlington Northern - Whitefish	01-30-87
Butte STP (Sewage Treatment Plant)	04-30-87
Lolo STP	06-30-87
Champion Bldg. Products	08-31-87
+Missoula STP	09-30-87
+Stone Container Corporation	10-31-87
*Kalispell STP	11-30-87
Anaconda Company	01-31-88
Anaconda Company	02-28-88
Town of Polson	02-28-88
City of Hamilton	04-30-88
Rocker Water & Sewer District	05-31-88
+City of Deer Lodge	06-30-88
Nicor Minerals Ventures	06-30-88
City of Ronan	09-30-88
City of St. Ignatius	09-30-88

+ Indicates discharges into streams (or reaches) for which flow reservations are requested or which will be directly influenced by them.

* These are in the Flathead River Basin above Polson, Montana.

[1/] Issued by the Dept. Health and Environmental Sciences.

all permits this table have been renewed by admin extension or issuance of new

Permits written for new or expanded discharges allow no changes from existing levels of coliform bacteria, dissolved oxygen, toxic and deleterious substances, or radionuclides where quality is higher than the established water quality standards. For other variables (pH, turbidity, temperature, color, suspended solids, or oils), the permit is written so that the applicable water quality standard is not violated, at least at receiving waterflows down to the 7-day, 10-year low flow.

b. Benefits

It is not possible to predict the type or nature of future industrial development, if any, in the upper Clark Fork basin. If industries were to develop that required a substantial, steady flow of water for operation, and no prior industrial water rights could be secured, then the instream flow reservation would have no beneficial effects. If prior industrial water rights could be obtained, then an instream flow reservation would assist in exercise of those rights. Substantial existing industrial water rights exist in the Warm Springs Creek drainage.

At a recent conference on Montana's economy, a leading economic authority stated that the nation as a whole is moving away from a manufacturing-based economy to a service-based economy, and that businesses which create new technology employ a smaller percentage of workers than do businesses which apply the new technology (Birch 1986). Emerging, young and growing, service-oriented companies may be the answer to Montana's economic future. Many of these companies are not constrained by distance to markets and they do well in remote areas like Montana (Birch 1986). The existing recreational opportunities in the upper Clark Fork basin, coupled with planned improvement in the quality of the riverine and riparian environment add measurably to the attractiveness of the area for these businesses, who often base site selection for their companies on amenities and environmental quality.

An instream flow reservation, combined with reclamation in the upper basin, will add materially to the area's recreational opportunities and quality of life. Improved environmental quality combined with the traditionally pro-business attitude of the Butte, Anaconda and Deerlodge areas would increase the attractiveness of the upper Clark Fork for these small, non-polluting firms.

Tourism is becoming the second or third largest industry in the United States and has been Montana's most important source of growth since 1980 (Birch 1986). Existing recreational resources in the upper Clark Fork are currently attractive to tourists (Hagmann 1979). Improved water quality in the Clark Fork River resulting from mining reclamation should make the area even more attractive to these visitors if sufficient streamflows can be maintained in the river. The only means of ensuring such streamflows under Montana's current water allocation process are by instream flow reservations.

An instream flow reservation will also benefit industry by helping to maintain flows for hydropower use at Milltown Dam and those plants on the lower Clark Fork. It will also provide needed dilution water to meet the requirements of current and future waste discharge permits issued in the middle and lower Clark Fork basin. By helping to maintain existing water quality of downstream receiving waters, these flows will (1) prevent the more frequent occurrence of flows less than the 7-day, 10-year low flow, thereby reducing the frequency of water quality standards' violations for those variables regulated by numerical limits, and (2) assure sufficient dilution water to render certain potentially toxic and deleterious substances harmless, or less harmful, to beneficial uses.

c. Impacts

Reservation of instream flows in the Clark Fork drainage will have no impact on existing industry, but may affect future industrial development. Although it is not possible to accurately predict the extent of future industrial development, it is probable that there is a potential for some new precious metal mines opening within the next several decades (Hayden 1984, personal communication). If it is assumed three small mines, employing state-of-the-art technology, are potentially feasible within the basin, the impact of the instream reservation on future industry can be predicted.

In order to predict the future water requirements of three new moderate-sized mines, data were obtained from the Montana Department of State Lands (DSL) on production and water requirements for two existing or planned precious metal mines in western Montana. The water requirements for the Golden Sunlight Mine near Whitehall and the proposed Montoro Mine near Butte (both moderate-sized, high-technology mines) are 700 and 500 gallons per minute (gpm), respectively. During normal operation these volumes of water have to be continuously supplied for "make-up" water.

If three new similar-sized mines opened in the future within the Clark Fork basin, approximately 600 gpm would be required for operation of each mine. If these new mines were located where instream flows are reserved, the mines would probably not be able to divert the required flow of 600 gpm from surface water on a year-round basis during all years. It would be necessary that groundwater be pumped or impoundments be constructed to consistently provide the needed water.

Depending on the economics of the future mines, it may not be feasible to pump groundwater, construct an impoundment or develop some other alternate supply. If water could not be supplied economically, mining could be adversely affected in those areas where water is reserved in streams with relatively low flow volumes.

4. Municipalities

a. Existing Situation

Municipalities in the upper Clark Fork basin rely on both surface and groundwater for public water supplies. Philipsburg and Butte pump surface water for public use; however, Butte's water comes from the Big Hole River, a tributary of the Missouri River. Anaconda, Deer Lodge and the state hospitals at Galen and Warm Springs pump groundwater, but Anaconda also has facilities in place which divert surface water to augment ground water. Drummond, Elliston, Garrison and Rocker do not have public water supplies; however, Drummond is planning to develop wells for a public water supply.

In addition to providing domestic water, the upper Clark Fork drainage also receives wastewater from municipalities and residences within the basin. Wastewater enters the rivers and streams as treated effluent from secondary sewage treatment facilities, as seepage from septic tanks and cesspools and in some instances as raw sewage. Butte, Deer Lodge, Philipsburg, Drummond and the state hospitals at Galen and Warm Springs provide secondary treatment of wastewater before it is discharged. Anaconda's sewage treatment facility operates in such a manner that no effluents are released to surface waters.

Sewage from Avon, Elliston and Opportunity enters surface waters as seepage from cesspools and septic tanks. At Opportunity, however, transport of this seepage to the Clark Fork is relatively rapid and direct via the ditches and drainage tile network installed to lower high groundwater levels.

In the past, Garrison and Rocker have had small sewage treatment facilities, but these facilities are currently not operating. Consequently, most of the raw sewage from these small communities directly enters surface waters.

At least 40 facilities are permitted to discharge treated wastewater in the Clark Fork River Basin (See Table 16). Twelve (12) of these facilities discharge treated wastewater to streams for which the Department of Fish, Wildlife and Parks has applied for reserved flows, or they discharge into streams (or stream reaches) which will be directly influenced by the flow reservation.

Permits written for existing discharges are designed to prevent exceedence of numerical water quality standards (for coliform bacteria, dissolved oxygen, pH, temperature, turbidity, and color) down to the 7-day, 10-year low flow of the receiving water. For variables that do not have numerical standards (sediment, nutrients, toxics, and other deleterious substances), no increases are allowed above naturally occurring concentrations which would create a nuisance or render the receiving water harmful, detrimental or injurious to beneficial uses.

Permits written for new or expanded discharges allow no changes from existing levels of coliform bacteria, dissolved oxygen, toxic and deleterious substances, or radionuclides where quality is higher than the established water quality standards. For other variables (pH, turbidity, temperature, color, suspended solids, or oils), the permit is written so that the applicable water quality standard is not violated, at least at receiving waterflows down to the 7-day, 10-year low flow.

b. Benefits

An instream flow reservation will maintain the existing fishery values and stream-related recreation opportunities on those streams where adequate stream flows are reserved. In addition, it will provide the opportunity for expanded fish populations in certain sections of the upper Clark Fork River when reclamation efforts are instituted.

Water-based recreation is important to the economies of the communities in the upper Clark Fork basin. The expenditures by recreationists are for travel, food, lodging, camping fees, equipment and other goods and services. These expenditures contribute to the economic well-being of the area and the municipalities in the upper basin. It should be noted that opportunities exist to expand fisheries in the mainstem Clark Fork which would provide for increased recreational opportunities. Increased stream-based recreation would provide additional economic benefits to the communities of the upper Clark Fork.

Maintaining minimum instream flows would provide benefits to municipalities by ensuring that adequate surface water will be available to dilute and purify wastewater discharges. By helping to maintain existing water quality of downstream receiving waters, these flows will (1) prevent the more frequent occurrence of flows less than the 7-day, 10-year low flow, thereby reducing the frequency of water quality standards' violations for those variables regulated by numerical limits, and (2) assure sufficient dilution water to render certain potentially toxic and deleterious substances harmless, or less harmful, to beneficial uses. Because most cities and towns in the basin discharge wastewater to rivers and streams, adequate flows must be maintained to allow the current waste discharges to continue, to preserve water quality, and to prevent jeopardy to public health.

An instream flow reservation may also help reduce the costs of future municipal pollution control facilities. Without adequate dilution water in streams, municipalities could have increased costs for more sophisticated waste treatment equipment than presently required to meet waste discharge requirements.

c. Impacts

Reserving instream flows in the upper Clark Fork drainage will probably have no negative impacts on municipalities within the basin. Census data (Table 17) from 1940 through 1982 show that the populations of communities in the basin have not increased much since 1940 (except for certain peak periods) and are now actually lower than in 1940 in some communities. The population of the basin was highest in 1980 and has since declined. In view of the declining population trend, existing water supplies and historical use rights will probably be ample to accommodate future growth. If rapid population growth should occur, additional municipal water would be available from ground water sources for some communities.

Table 17. Populations of municipalities in the upper Clark Fork basin.

Municipality	1940	1950	1960	1970	1980	1982
Anaconda	11,004	11,254	12,054	9,771	12,518	11,583
Butte	37,081	33,251	27,877	23,368	37,205	35,753
Deer Lodge	3,278	3,779	4,681	4,306	4,023	3,978
Drummond	-----	531	577	494	414	440
Philipsburg	1,304	1,048	1,107	1,128	1,138	1,153
Total	52,667	49,863	46,296	39,057	55,298	52,907

SOURCE: U.S. Bureau of Census.

5. Fish, Wildlife and Recreation

a. Existing Situation

In a previous section of this application, the status of existing fish and wildlife populations in the Upper Clark Fork basin is described for those streams where instream flow reservations are requested. Briefly, the Upper Clark Fork River has two sections which contain good to excellent fish populations. These sections are immediately below Warm Springs Creek and from Rock Creek to Milltown Reservoir. In those sections, habitat conditions and water quality are good. In other sections of the river, however, the fish populations are considerably below what they would be with improved habitat and water quality. In those sections, water quality is often poor due to leaching of mine tailings on the banks and in the floodplain. In addition, past stream channel alterations due to highway and railroad construction have impacted the aquatic habitat, and summer streamflows are very low due to irrigation.

Tributary streams to the Upper Clark Fork are important to Clark Fork River fish populations for several reasons. Tributary streams provide a source of clean water to dilute the pollution load in the main river. Additionally, they provide critical spawning areas for mainstem fish populations. Natural reproduction is limited in the Upper Clark Fork due to water quality and habitat limitations. Tributary streams often contain good to excellent resident fisheries. The tributary streams described in this application provide important spawning areas for Clark Fork River fish, contain good resident fisheries, or both.

Hagmann (1979) conducted a recreation use study on the Upper Clark Fork and four of its major tributaries from June, 1978 to June, 1979. The study had two primary components: (1) observation of visitors and vehicles by the study team (this was used to generate use pattern estimates); and (2) administration of a questionnaire to recreationists age 15 and older. The questionnaire asked recreating visitors about previous use of the river and other rivers in Montana, characteristics of their current visit, evaluations of access and quality, group composition, and residence.

Of the 986 persons who completed questionnaires, about 70 percent were Montana residents, showing the Clark Fork's value as a local recreation resource. About 25 percent of the residents were visiting the river for the first time, while 15 percent had visited the river for 20 years or more. Thirty-two (32) percent visited the Upper Clark Fork or its tributaries 10 or more times a year, 30 percent 3-9 times a year, and 22 percent once or twice a year.

About 38 percent of the residents lived in Missoula, 12 percent in Helena, 10 percent in Butte, and 17 percent in smaller towns near the river.

Fishing was the most popular recreational activity for Montanans and was engaged in by 83 percent of the residents interviewed. The next most common activity was simply rest and relaxation (participated in by 45 percent of the residents), walking or hiking (36 percent), picnicking (34 percent), sightseeing (26 percent), water play, including swimming (21 percent), and floating (20 percent). This information highlighted the importance of fishing to residents visiting the river.

Residents listed fishing and recreating close to home as the two most important reasons for visiting the Clark Fork and its tributaries instead of other rivers. When asked what other streams they visited the most, 17 percent of the residents listed the Blackfoot and 12 percent the Bitterroot; no other river was visited by more than about six percent. The Bitterroot and Blackfoot rivers are likely the two closest substitutes for comparable river recreation in the Missoula area.

Fishing also was a popular activity among non-residents (52 percent were fishing or planned to fish); rest and relaxation was engaged in by 56 percent, walking or hiking by 44 percent, sightseeing by 42 percent, recreational vehicle camping by 38 percent, and floating by four percent of those interviewed. Hagmann's results portrayed the Clark Fork as a valuable local recreational resource that was favorably compared to other Montana rivers even though it was not always preferred by some users. Its prime attractions for residents were fishing, coupled with closeness to home. Fishing was by far the most popular recreational activity, and most of the floaters probably were fishing as well.

Based on the observations of recreation visitors, Hagmann estimated that the Clark Fork and the four tributaries received about 103,000 recreational visits during the study year, with about 80 percent of this use occurring during the summer season (Winter use on Flint Creek, the Little Blackfoot, or Warm Springs Creek was not measured, so the above use estimate is conservative). Use level data were not broken out by month, but non-resident use likely peaks during mid to late summer, when most persons take their vacations.

Use levels were heaviest at campgrounds and locations having good vehicle access, including Milltown Dam, bridges near Turah and Beavertail campgrounds, Schwartz Creek and Rock Creek, and undesignated campsites near Kading campground on the Little Blackfoot River.

Hagmann used observations to estimate the use levels by activity, but these results were suspect. For example, only about 45 percent of the visitors observed were fishing. This proportion was used to calculate a fishing use level of about 31,000 visits annually. However, questionnaire results showed that 74 percent of all respondents reported they were fishing.

This difference suggests that fishing use may have been underestimated, perhaps due to a bias in observations [persons who did not happen to be fishing when viewed by the study team would not have been counted as anglers. In addition, Hagmann reported that about 70 percent of the total number of persons using the areas during the survey were not given questionnaires "because many cars were sighted and the occupants could not be found" (p. 22)]. She assumed that these non-respondents did not differ from respondents, but it is reasonable to hypothesize that this group would indeed differ from visitors staying close to their vehicles. Many anglers probably fished upstream or downstream from their vehicles, so were unavailable for interview.

Similarly, floating use may have been underestimated; 20 percent of the questionnaire respondents reported floating, but only about three (3) percent were actually observed; the use level of about 3,500 visits (annually) was derived from observational data, not from the questionnaire survey. Floaters likely were not seen from observation points.

It would be useful to know if use of the Upper Clark Fork is increasing, remaining constant, or declining. In the absence of comparable trend survey data, use level changes can only be estimated.

In his analysis of Hagmann's data, Duffield (1981) estimated that use of the Upper Clark Fork could increase 1.24 percent annually, because this was the projected growth for Missoula County, the primary market area. However, the population in the four counties which comprise the Upper Clark Fork Basin decreased by 0.8 percent in aggregate from 1980 to 1984 (Bureau of Business and Economic Research 1985).

Use levels on the Upper Clark Fork are likely remaining fairly steady. Changes in the physical, social, or managerial aspects of the Upper Clark Fork area, however, would potentially affect this rate. The requested instream flows would maintain recreational use and/or the present quality of recreation and allow for the eventual enhancement of these activities. The precise levels of increased benefits are unknown and can only be estimated from other research.

The Upper Clark Fork plays an important role in the spectrum of river recreation opportunities in western Montana. In his remarks to the Clark Fork Coalition in Missoula, March 22, 1986, Governor Schwinden detailed past abuses of the Clark Fork and present attempts to mitigate them:

> "For almost a century, the Clark Fork River fell victim to the mining companies and townspeople who worked and lived on its banks. The river was a convenient, cheap dumping ground. Its waters carried the burden of their refuse and their disregard--and little else. Today, we know more and we care more. In the 1980's we have recognized the opportunity--indeed the responsibility--to bring the Clark Fork back to life...we have made a start and, as we approach our Centennial, we can feel proud that, in Montana's second century, the Clark Fork will gradually be restored to what a river should be-- a source of life and of inspiration to those whose lives touch it."

The requested instream flow reservations are one component of this effort--an attempt to maintain and enhance recreational opportunities on the Upper Clark Fork and its tributaries. The public's concern for water quality in the Clark Fork is clear considering the level of public comment given on the State Water Quality Bureau's recent decision to modify the discharge permit of a mill on the river downstream from Missoula.

b. Benefits - social

Water is probably the greatest of all outdoor recreation attractions (Craighead and Craighead 1962). In one study of recreation behavior, 38 percent of all recreation involved water (Cheek and Field 1977). Rivers are essential for activities such as fishing, boating, or swimming. They provide an aesthetic back drop for other activities and enhance the pleasures of picnicking, hiking, driving for pleasure, and just relaxing.

The value of a river for recreation is partly a function of its streamflow, water quality, and riparian attributes (Hendrikson and Doonan 1972). A uniform streamflow (or one that does not fall below a minimum level) enhances recreational value not only because fisheries habitat is preserved, but because the resource is more "reliable". Recreational utility and appeal increase if streamflows are maintained during periods of drought, or when there are competing demands for water.

Instream flows benefit recreational use in many ways. Perhaps the most obvious is enabling recreation activities that require water. Maintaining flow levels that provide adequate fish habitat can sustain good fish populations--which translates into high quality fishing experiences. Similarly, streamflows above a given level are required to physically permit boating on streams and rivers (Cortell and Associates 1977; Hyra 1978).

Water also enhances activities that do not depend on its presence, such as picnicking, hiking, or driving for pleasure. It is, therefore, appropriate to consider the "passive" recreational user of water when estimating the effects of possible management actions (Kaplan 1977). Reduced flows could decrease river aesthetics by increasing algae blooms created by shallower, warmer water.

Knopp, et.al. (1979) found that water quality, wildlife, rock formations, some rapids, and good fishing were the setting attributes most preferred by river users. Water quality is crucial, and can even contribute more to recreational satisfaction than size or number of fish caught (Moeller and Engelken 1972).

Among river-related activities, fishing and boating stand out because of their long-standing popularity and direct dependence on instream flows. Fishing is one of the most popular recreational activities nationwide, closely following nearly-universal activities such as walking, driving for pleasure, and picnicking (Heritage Conservation and Recreation Service 1979).

Fishing is especially popular among Montanans. A 1985 statewide survey found that 56 percent of the random sample interviewed had gone fishing a median of 12 days in the preceding year (Frost and McCool 1986). Unlike nearly all other outdoor activities pursued by residents, fishing is popular among all age groups, tapering off only slightly (to 43 percent) among those 65 and older.

Moreover, the same survey asked Montanans what activities they would like to participate in but do not. Fishing was listed more times than any other summer activity and ranked third among all activitites. The major barrier to participation in fishing was "lack of time", mentioned by nearly two-thirds of the sample. This points to the value of rivers located near populated areas because the local fisherman does not have to travel far to enjoy fishing.

Persons fish for many reasons. The most obvious, naturally, is to catch fish, but other important aspects of fishing experiences include enjoying nature and scenery, escaping the stresses of everyday life and work, exercise, testing fishing skills, gaining a sense of accomplishment, and socializing with friends or family (Driver and Knopf 1976; Driver and Cooksey 1977). These are all examples of psychological benefits that can result from fishing experiences, and are important in understanding the value of the Upper Clark Fork as a stream fishery.

River floating is another activity meriting special consideration on the Upper Clark Fork. The 1985 statewide survey (Frost and McCool 1986) found that 25 percent of the sample had floated a river during the last twelve months. In DFWP Region 2, where the Clark Fork is located, 32 percent of the respondents had floated a river. When asked why they chose a particular river to float most frequently, nearly 70 percent cited convenient access. The second most-common reason was fishing opportunities.

The quality of water and abundance of fish in the Upper Clark Fork play a significant role in the distribution of recreational use. Good fish populations and high water quality prevail in sections of the river from Rock Creek to Milltown and just below Warm Springs Creek. More than 60 percent of the summer recreational use occurred in these accessible sections even though they comprise less than one-third of the river. The potential for expanded recreational use on the remainder of the river, given adequate instream flows and successful reclamation efforts, is high. Knudson (1984) estimated that the Clark Fork River in its worst section (the Bearmouth area) is at only about 2% to 3% of its potential for supporting fish populations when compared to the Blackfoot River and Rock Creek, respectively.

Based on the average size of the fish populations in all reaches of those two streams, some reaches of the Clark Fork are still at only 12% to 20% of their fishery potential.

In a further examination, Knudson (1984) compared the fishery of the Blackfoot River with the Ennis section of the Madison River in southwest Montana. Both streams contain about 2,500 trout per mile. The Madison River is a world-renown fishing stream. Similarly, a completely healthy upper Clark Fork River, with fish populations approaching those of its two major tributaries, has the potential to become a first-class fishery (Mining pollution abatement in the headwaters has already allowed a short stretch of the river below Warm Springs Creek to produce over 2,000 brown trout per mile). An instream flow reservation will help accomplish this objective. Maintenance of existing recreational opportunities through this instream flow reservation request is clearly a public benefit and, therefore, in the public interest.

c. Benefits - economic

Demands for the land and water resources which support fish, wildlife and recreational activities are growing, and the need for good information on which to base sound resource allocation decisions is increasing in importance.

The determination of how to distribute the water resource is partially based on the economic benefits provided by the resource or its use. Most of these economic benefits are quantified in dollar terms under actual market situations. That water simply provides a home for fish is not normally a sufficient argument in the allocation process. There is no question that fish, by providing the opportunity for fishing, generate economic benefits. Fishermen spend money for food, lodging, fishing equipment, guide or outfitting services, boats, and other fishing-related products and services. Many recreational benefits are, however, nonmarket in nature. The non-market nature of these benefits makes it quite difficult to determine their economic values. Consequently, there have been misunderstandings and reluctance to use calculated economic values for recreational activities in the allocation process. However, Copeland, et. al. (1976) state that this lack of quantification should not exclude these non-market values from consideration by decisionmakers.

Economic values for all outputs (resources) are defined in terms of net willingness to pay (amount in excess of actual expenditures) by users (Sorg, et al. 1985). The Travel Cost Method and the Contingent Valuation Method have been accepted and adopted in the Federal Register and in Water Resources Principles and Guidelines. Both these methods provide estimates of net willingness to pay for fishing.

The Montana Department of Fish, Wildlife and Parks is currently conducting a statewide fishing preference and valuation study.

This study will provide "net willingness to pay" values for cold water stream fishing on an individual site basis, including the Clark Fork River. Both the Travel Cost and the Contingent Valuation Methods are being used to calculate these values. Results should be available in December 1986.

A number of other studies have demonstrated the economic values of rivers for recreational use. Between 1982 and 1986 the DFWP estimated that over two million angler-days were spent fishing Montana waters in each of those years (DFWP 1986b). In FY 1985, over 600,000 resident and nonresident fishing licenses were sold in the state and they produced revenue of over $5.98 million (Sport Fishing Institute 1986). Also in that year, Montana sold the third highest number of nonresident fishing licenses in the nation (out-ranked only by the more populous states of Wisconsin and Michigan) despite the fact that the state is relatively remote. Results of the National Survey of Fishing, Hunting and Wildlife-Associated Recreation in Montana for 1980 showed that total expenditures in Montana by all fishermen 16 years old and older were over $75 million. Each fisherman contributed an average of nearly $300 ($20 per day) to the State's economy that year. An analysis by DFWP in 1983 showed that resident and nonresident fishermen contributed over $87 million to Montana's economy (excluding all license costs) (DFWP 1983).

The above figures combine lake and river fishing. However, a survey of non-resident anglers who visited Montana in 1982 found that about 65 percent of the waters fished were rivers, while only about 16 percent were lakes; the rest were mixed waters or not reported. Sixty-nine percent said they decided to fish in Montana because of the quality of fishing. One-half said fishing was the primary purpose of their Montana visit (Montana State University 1983). This suggests that non-resident anglers visit Montana primarily for opportunities to fish rivers. Fishing is also a reason many Montanans choose to live here, and it increases the quality of their lives.

The amount of money contributed to local economies, or even the total amount spent on fishing or boating outings, however, is not a valid estimate of the value of recreation experiences. Such expenditures reflect only the amount allocated to the experience. A more accurate measure of value is how much more recreationists would be willing to pay for those experiences -- the net value of recreation visits above and beyond actual travel costs (Loomis, Peterson and Sorg undated).

Economic values for river recreation have been estimated using the travel cost and contingent valuation methods. Studying the economic value of recreational steelhead fishing on 11 Idaho rivers, Donnelly and his colleagues (1985) found that the average willingness to pay above and beyond actual expenditures was about $28 per trip (using the travel cost method) and $31 per trip (using the contingent valuation method) over actual expenditures of about $72 per trip. Anglers on all 11 rivers were willing to pay more for an increase in the number or size of fish caught.

A similar survey of cold water (trout) fishing (Sorg, et al. 1985) found that anglers were willing to pay an average of $43 over and above their actual expenses (an average of $37) to gain the same experience.

In a review of the literature, Loomis and Ward (1986) found values between $21 and $28 per day for whitewater boating and tubing, $22 to $24 per day for recreational use of Wild and Scenic rivers, and $16 to $17 per day for use of non-designated rivers. Values for use of nationally known rivers such as the Middle Fork of the Salmon in Idaho were up to $176 per day (in 1982 dollars). This estimate approximates the amount paid to outfitters for river trips on the Salmon and comparable rivers.

Higher values than these have been found using a compensation (willingness to sell) variation of the contingent valuation method, a more appropriate method to value losses in existing recreational quality (Duffield 1984).

Research has demonstrated that river users are willing to pay more to specifically maintain or improve water quantity and quality. Walsh, et. al. (1980) analyzed the public benefits from cold water river fishing, kayaking, and rafting on the west slope of the Rockies in Colorado. Average benefits from angling were reported to be about $20 per day. Diversion of instream flow below that which was present on interview days would have substantially affected the estimated total benefits; a 50 percent reduction in flow resulted in a reduction in average fishing benefit to $9.57 per user day.

Increases in instream flow were most valuable for both fishing and boating during late July, August, and September, when recreation began to compete with other uses for decreasing amounts of water. The authors noted that recreation values may conservatively estimate the total benefits of instream flow because long-term ecological effects were not included.

A similar study of the economic benefits associated with instream flow levels was conducted on the Poudre River in Colorado (Daubert and Young 1979). The relationship between willingness to pay and optimum flow was curvilinear; anglers would have paid more to achieve flow levels approaching the optimum, and then paid less for additional increases (zero beyond a certain level). When the Poudre's flow was very low (about 50 cfs), however, the marginal benefit was relatively large, ranging from $26.38/cfs to $36.59/cfs.

Another study showed that visitors were willing to pay more for higher water quality. Walsh, et. al. (1978) showed visitors to Rocky Mountain National Park color photos depicting six levels of water quality in the South Platte River Basin and asked how much they would be willing to pay to guarantee that level of water quality. The average benefit of obtaining the highest level of water quality instead of the lowest was $5.42 per household recreation day. Visitors also said they would increase travel time by 89 percent to obtain high water quality.

The marginal benefits of water quality improvement also were curvilinear, rising most rapidly at a water quality index near 70 units (on the survey scale) and less rapidly at higher and lower water quality levels. This suggested that there was an optimum (economically efficient) level of water quality, beyond which persons would be willing to pay less for incremental increases in quality.

These studies show that instream flow does have economic value to users (and probably indirect value to users and non-users as well). Anglers and boaters often know when levels are at a minimum, optimum, or maximum level, and they regulate their recreational use accordingly (other factors affecting recreational site choice remaining equal). The net recreational benefits of instream flow increase rapidly as flow approaches the optimum level for given recreational activities and then drop off as flows increase to the point where activities are affected negatively.

An estimate is available of the economic value of recreation along the Upper Clark Fork River. Duffield (1981, 1984) used a travel cost methodology to analyze Hagmann's (1979) survey data to estimate the value of recreation on the Upper Clark Fork and three of its primary tributaries--Flint Creek, Warm Springs Creek, and the Little Blackfoot River. The following discussion summarizes these data; readers should consult Duffield's papers for a complete version.

The travel cost method derived a demand curve for use of the Upper Clark Fork by examining the visitation rates (such as visits per capita) corresponding to travel costs from zones at various distances from the site. Travel cost was viewed as the supply price that rations use of the recreation setting. By plotting visits against travel costs, the demand curve shows the number of trips a visitor would make at alternative travel costs.

The demand curve traced the relationship between site use and price (travel cost) from consumption at current costs to where the number of trips taken would equal zero. The area under the demand curve, called "consumer surplus", represented recreation visitor's net willingness to pay for the visit in addition to existing expenditures (travel cost).

Developing estimates of recreational values using the travel cost method involved several steps. Multiple regression analysis was used to define the important parameters of upper Clark Fork River use. Travel cost (estimated to be about 7 cents per mile for the summer of 1978), per capita income of the origin counties, and the availability of alternative recreational river sites were used to develop equations predicting visit rates per capita from various counties in Montana.

To derive the river's benefits to a given county or town, the resulting visit rate equations were integrated with respect to travel cost. This value was then multiplied by the population of each origin site (county or town) from which people visit the river. The sum of these values was the estimate of the river's value for recreation.

The value of visits by nonresidents (or residents living more than 150 miles away) was estimated to be either zero (a conservative approach) or the same as for residents, even though nonresidents may have traveled much farther to reach the upper Clark Fork. It was assumed that travel costs of individuals traveling from more than 150 miles away couldn't be attributed entirely to the Clark Fork because they likely were on a multiple-destination trip, only one part of which was fishing along the river. It would have been misleading to attribute the entire travel costs incurred by distant residents to a Clark Fork visit, but in the analysis they were assumed to be zero, even though the visit to the Clark Fork added some value for some of the visitors. This was one of the many statistical and methodological modifications needed to develop the conservative value estimates.

This process yielded average values per visit to the upper Clark Fork. Hagmann's use level estimates were multiplied by these averages to obtain estimates of the annual value of recreation. From these estimates, Duffield calculated the present worth of recreational benefits, based on the discount rate applied to future revenues, projected changes in recreational use levels, and inflation rates.

Based on an average value of $4.85 to $5.77 per visit, the annual estimated recreational value generated by the Upper Clark Fork Basin ranged from $304,000 to $468,000 (1984 dollars) depending on the specific assumptions made. The present net worth of recreation (the value now of all future visits given current conditions and trends) was $7.5 to $11.5 million, once again depending on which conservative assumptions were used in the analysis.

Some of these assumptions were necessary because Hagmann's (1979) survey questionnaire was not designed specifically for a travel cost analysis. Conservative assumptions were made so the value obtained could be considered a base minimum.

Furthermore, only 57 percent of the non-resident visits were included in the analysis based on non-residents' reasons for visiting the Clark Fork. Many reasons given, such as "just passing through", indicated that not much travel cost should have been attributed to the visit. Other non-residents' responses, such as "for the fishing" indicated a likely higher value for the experience. The ratio of the types of answers indicating higher value to all answers was 0.57, the percent chosen for the analysis. The non-resident visits also were assumed to have the same value as resident visits. Duffield (1984) reviews the other assumptions resulting in a conservative estimate.

The per-visit low and high estimates were somewhat below the range of values recently estimated for other recreation settings in Montana and Idaho, which included (all in 1984 dollars) $6.04 to $10.43 per visit to Kootenai Falls (Duffield 1982), $6.96 for visits to Flathead Lake and River (Sutherland 1982), $6.12 to $10.28 for visits to Rock Creek (Duffield 1984), and $24.09 for coldwater fishing visits to Idaho (Sorg, et. al. 1983). Because the estimates were very conservative, these values indicate substantial economic benefits to be derived from maintaining the existing recreational opportunities. With adequate streamflow and improved water quality, the Clark Fork's recreational value would likely increase.

For comparative purposes, recreational use estimates and a corresponding economic evaluation were done for Rock Creek (Duffield 1984). Rock Creek, a tributary to the Clark Fork River, is a relatively pristine drainage having good water quality and excellent fish populations throughout its length. Duffield's estimate of the annual value generated by recreational use of Rock Creek is $945,000 to $1,590,000. The present net worth of recreational use on Rock Creek is $25 to $45 million.

Based on Hagmann's study, we would not expect the Clark Fork to be as highly valued a destination fishery as Rock Creek, or, perhaps the Madison River. Even though Duffield (1981) estimated the economic values for Rock Creek as about four times that of the Upper Clark Fork and its main tributaries, the data clearly show the Clark Fork is a valuable recreation setting, particularly for nearby Montana residents.

Yet even knowing how much persons would pay for recreational use of rivers greatly underestimates their total value because this amount does not include three types of indirect values: (1) Option Values are derived from knowing one can visit a setting in the future; (2) Bequest Values are derived from knowing that future generations will have the chance to use recreational resources; and (3) Existence Values are derived simply from knowing a resource exists, even if it's never used. Many persons may never visit Alaska, for example, but they gain satisfaction just knowing it's there. Indirect values can exist for both users and non-users of a resource.

A recent study of 11 rivers proposed for Wild and Scenic designation in Colorado found that resident households were willing to pay an average of $95 per year, a total of $113 million, to protect these rivers (Walsh, et. al. 1985). Direct recreation use values (values derived by current resource users) accounted for $21 million, option values $18 million, bequest values $41 million, and existence values $32 million. The indirect values thus accounted for over 80 percent of the total value. A study of Montana's Flathead Lake and River system reached a similar conclusion; the estimated annual value of recreational use was about $5 million, while annual indirect values were about $100 million (Sutherland 1982). Incorporating indirect values would, therefore, have increased the Clark Fork's value by a factor of two to ten.

While the Clark Fork River will never equal the pristine watershed and habitat conditions found in Rock Creek, a reclaimed Upper Clark Fork River having adequate streamflows would foster good fish populations and recreational opportunities, and could add substantially to the economic base of the area. Therefore, it is clearly in the public interest to reserve adequate instream flows and allow that opportunity to occur.

d. Impacts

There are no adverse environmental impacts or other impacts to the fish, wildlife and recreational resources of the area associated with this reservation application.

e. Instream Flow Requirements for Boating

The assumption is made that the flow level which adequately protects fish habitat and production will, in turn, maintain fish populations at a level that will attract fishermen. Fishermen tend to seek out those waters having higher fish numbers and better catch rates. A logical and well-founded conclusion is that flows that protect fish also benefit fishing. Another assumption is that other water-based recreational activities, the most notable being boating, also benefit. Boating (rafting and canoeing) is the second most popular (after fishing) recreational activity on the upper Clark Fork River that depends directly on flow levels. The purpose of this section is to analyze this assumption for boating opportunities.

Two stream factors--width and water depth--are probably the most important physical characteristics that determine the level of boat use and the types of craft employed. Water velocity can also be an important consideration. Basically, velocity functions to change an activity from tranquil water boating to whitewater floating. For purposes of this discussion, the analysis will focus on depth and width, the most critical variables.

Minimum depth and width criteria for various floating craft have been derived by researchers. Hyra (1978) lists 0.5 feet as the minimum stream depth required for canoes and kayaks and 1.0 foot for drift boats, rafts and innertubes. Minimum stream width for canoes, kayaks and tubes is 4 feet, and for drift boats and rafts, 6 feet. No optimum criteria were given.

Cortell and Associates (1977) list a slightly lower minimum depth for canoes and kayaks--3 to 6 inches--and 1.0 foot for rowing craft (rafts and drift boats). Their optimum depth is 2 to 5 feet for both activities. Minimum width is one (1) times the length of the craft, or more realistically 25 feet for canoes, kayaks and rowing craft. Optimum width is 75 feet or more for all craft (As will be discussed later, this width may not be realistic for the Clark Fork). These width criteria appear to be more realistic than the width values of 4-6 feet cited by Hyra (1978). Successfully passing a floating craft through a 4-6 foot slot would undoubtedly be a difficult task for a novice boater, particularly on a rapidly flowing river. It should be noted that the Hyra minimums would not provide a satisfactory boating experience if much of the river exhibited such depths and widths.

A commonly used approach when deriving instream flow recommendations for recreational boating is to establish a single cross-section or a number of cross-sections in the stream area that provides the greatest obstacle to boat passage. This is typically the widest, shallowest riffle area in the stream reach of interest. A hydraulic simulation computer model, such as the one used in the WETP program, is calibrated using field data collected for the cross-sections, and predictions are then made of the cross-sectional depths and widths at a range of different flows. From this information, one is able to establish at which flow the minimum passage criteria for depth and width are first satisfied. The underlying assumption of this approach is that if this area--the most difficult for boat passage--provides the necessary depth and width to support boating, then the remainder of the stream would as well.

When the wetted perimeter inflection point method was applied to the Clark Fork River to determine the instream flow needs for fish, cross-sections were established in areas classified as typical stream riffles. These were wide, shallow areas, but not the widest, shallowest riffles in each reach. Consequently, these riffle cross-sections do not reflect the most critical area in the stream reach for boat passage. If the minimum depth and width criteria for boating are satisfied for these cross-sections by a particular flow, there may still be wider and shallower riffles--the atypical ones--where the minimum criteria are not met by this flow. A minimum boating flow derived using the existing cross-sectional data for the Clark Fork River would, therefore, underestimate the flow required to support boating on the entire river reach. However, as with many stream boating experiences, there are times when a portage past an obstacle is required. In the case of the Clark Fork, the obstacle may be a riffle shallower than the ones selected for the WETP analysis.

The existing cross-sectional data for Clark Fork Reaches 1, 2, 3 and 4 were analyzed to determine if the flows at the low and high inflection points were favorable for boating. Criteria examined were (1) the stream widths providing depths greater than or equal to 1.0 foot--the minimum required for drift boats and rafts--and (2) stream widths providing depths greater than or equal to 2.0 feet--the optimum for these craft. Because more than one riffle cross-section was established in each reach, the most critical cross-section, i.e., that one having the lowest width value (in feet) of all of the cross-sections in each reach, was selected for this analysis.

Table 18 shows the results of this analysis. The high inflection point flow recommendations for all four Clark Fork reaches easily satisfy the minimum criteria for rafts and drift boats (at least 25 feet of stream having depths greater than or equal to 1.0 foot). However, high inflection point flows for all reaches failed, by a wide margin, to meet the optimum boating criteria (at least 75 feet of stream having depths greater than or equal to 2.0 feet).

At the low inflection point flows, minimum boating criteria were not met in Reach 1 and barely met in Reaches 2 and 3. If cross-sections had been placed in Reaches 2 and 3 in the most critical areas for boat passage, it is likely that the minimums would not have been met in these reaches as well. Only in Reach 4 were the minimum standards substantially exceeded at the low inflection point flow.

Despite the limitations of these data (i.e., the placement of cross-sections), some conclusions can be made regarding boating potential. Neither the high or low inflection point flows for Clark Fork reaches 1, 2, 3 and 4 would provide optimum conditions (75' width, 2.0' depth) for floating in rafts and drift boats. However, the high inflection point recommendations will likely meet minimum boating standards throughout much of each of the four reaches. The low inflection point flows for Reaches 1, 2 and 3 would not provide a desirable floating experience on significant segments of each of these three reaches, and would likely eliminate floating altogether as a recreational activity. Only in Reach 4 would the low inflection point flow likely provide acceptable floating conditions throughout most of the reach.

Using Hyra's (1978) data, the minimum requirements (4'-6' width at 1.0' depth) would be met in all four reaches at both high and low inflection point flows.

Although the widths suggested by Cortell and Associates (1977) appear more realistic than those recommended by Hyra (1978), the application of the 75-foot optimum to the upper Clark Fork may be impractical due to the relatively small size of the river. Comparing this 75-foot requirement with the actual widths of the river in reaches 1 and 2 at the high and low inflection point

Table 18. Width and depth characteristics relating to boating on Reaches 1, 2, 3 and 4 of the upper Clark Fork River at high and low inflection point flows.

	Flow (cfs)	Stream width (ft) having depths ≥ 1.0 ft.	Stream width (ft) having depths ≥ 2.0 ft.
Reach 1			
High Inflection Point	180	37	5
Low Inflection Point	90	20	0
Reach 2			
High Inflection Point	400	37	19
Low Inflection Point	200	26	0
Reach 3			
High Inflection Point	500	56	14
Low Inflection Point	180	30	0
Reach 4			
High Inflection Point	600	95	25
Low Inflection Point	300	61	0

flows (Table 19), it can be seen that 75-feet is greater than the total water surface width of some cross-sections, and, where not wider, would still require that over 50 percent of the stream width would have to be at least 1.0 foot deep at the high inflection point flow. In reaches 3 and 4, this relationship would be more likely, but no more realistic considering the physical characteristics of the stream channel in these reaches. There is, therefore, every indication that the requested high inflection point flows will be adequate to meet boating requirements on the Clark Fork in all four reaches.

The time of year when boating on the Clark Fork is at the same time most popular and difficult is during the summer irrigation season when water in the basin is being diverted for out-of-stream uses. This is a present-day occurrence recognized by most river boaters. There is more water available in the river before and after the irrigation season and boating is easier during these periods. An instream flow reservation will not change the present situation (due to existing water rights) but will help assure that future boating conditions do not become less favorable during summer low-flow periods.

Existing data are not adequate to estimate the net economic value of differences in boating experiences at various flow levels.

Table 19. Width characteristics of cross-sections in Reaches 1, 2, 3 and 4 of the upper Clark Fork River at high and low inflection point flows.

	Inflection point flow (cfs)	No. of WETP cross-sections	Water Surface top width (ft) Max.	Min.	Avg.
Reach #1					
High	180	5	84	59	69
Low	90	5	81	59	66
Reach #2					
High	400	3	120	80	98
Low	200	3	74	51	67
Reach #3					
High	500	3	162	94	125
Low	180	3	98	63	80
Reach #4					
High	600	3	160	148	156
Low	300	3	135	119	130

However, previous research strongly suggests that boaters would be willing to pay more for each increment of water remaining in the river during the summer, because flow levels then are currently close to the minimum levels needed.

6. Alternative Actions

In discussing the adverse and beneficial environmental and economic effects of the reservation as required in the ARM rules, it became evident that any discussion must also include alternative actions. The alternatives chosen for discussion include three possible actions which could be taken by the Board of Natural Resources on this reservation application. These include (1) DFWP instream flow reservations are not granted; (2) DFWP reservations are granted in the full amounts requested; (3) DFWP reservations are granted in some lesser amounts.

(1) DFWP Instream Flow Reservations are not granted.

Acceptance of this alternative by the Board of Natural Resources would maintain the status quo as far as water allocations are concerned. Water use permits would continue to be issued on a first-come, first-served, piecemeal basis as they are now being issued--without adequate knowledge of water availability and usage. Water rights for instream uses would not be available and fish and wildlife resources would continue to suffer from further dewatering of streams. In the absence of legal standing, fish and wildlife resources would continue to be unrecognized during the issuance of water use permits, and they would continue to be degraded by the diversion of water for other uses.

Only through the process of determining existing water rights as first authorized by the 1973 Water Use Act and spurred by SB 76 (Ch. 697, laws of 1979), can new water use permits be reconciled with existing uses in a rational manner. However, it may be many years before this statewide process is completed. It has been estimated that it will be 10 to 20 years before all final decrees and water right certificates are issued (DNRC 1982, pg. VI-8). Thus adjudication is not a short-term solution to water allocation problems in the upper Clark Fork River basin.

Existing water rights in the river basin will at all times be honored. If the reservations here requested are not granted and approved, any waters available over and above such existing rights will be available for future appropriations by permit. If these future appropriations are allowed to be executed in advance of, or without, the reservations here requested being established, the fish and wildlife resources will be permanently deprived of the waters necessary for their healthy survival. It is apparent that, under our current water laws and regulations, waters once appropriated might never again be available for fish, wildlife and recreational purposes. The need for an adequate reservation now is clearly indicated.

The principal detriment of this alternative would be to instream water uses for fish and wildlife. Other beneficial consumptive water users would continue to obtain water as they needed it, while fish and wildlife resources would do with less amounts as the years went by. The losses to the public could, thereby, become irretrievable.

Interestingly enough, this alternative could result in detriments to other water users. Conflicts between current consumptive users could well be aggravated through the issuance of new water use permits. An approved instream flow reservation, by its very presence, acts as a buffer between existing right holders and potential future consumptive water users. Existing diversionary rights are protected by the instream flow which has a priority date senior to future permitees. By protecting its own instream flow, the DFWP protects the flow of senior diversionary water users when low flow events threaten water availability.

(2) DFWP reservations granted in full.

This action will very much favor instream uses for fish, wildlife and recreation. In those stream reaches currently not suffering from severe dewatering, existing levels of aquatic populations will be maintained. On those streams where water levels are already low due to summer irrigation withdrawals, and where the aquatic resources are currently not at optimum levels, granting of the reservation will help ensure that those populations are not further degraded by reduction in flow, and will, perhaps, allow them to increase in numbers in the long run. In the case of the Clark Fork River itself, granting the reservation in full will allow improvement of that aquatic community as mine waste reclamation is undertaken in the headwaters. Conversely, further dewatering added to the existing pollution problem can only cause further degradation of the stream, particularly if reclamation of mine wastes is prolonged or not completed.

Reclamation is already underway in the basin, providing significant potential to improve water quality and eliminate toxic metals pollution. Increasing instream flows during the critical summer months through such means as water storage projects, the purchase of irrigation rights for instream uses, and more efficient irrigation delivery systems will likely be investigated in the future. By granting the reservation in full, we will be ensuring future generations the opportunity to rehabilitate the fishery and associated recreational resources to levels that reflect the Clark Fork's true potential.

We have not requested instream flows for the high flow period on any stream for two reasons: (1) by law (85-2-316, MCA), our flow request cannot exceed 50% of the mean annual flow on gaged streams and (2) high flows annually recirculate toxic metals deposited in the bed and banks of the stream and carry them through the river system at least as far downstream as Milltown reservoir. If we were to request flows for this period we would exceed the 50% limitation, since most of the annual flow volume usually occurs during the high flow period. High flows are, however, necessary in streams to maintain channel morphology (which determines the quality of fish habitat) and contribute to maintenance of the riparian zone.

Channel maintenance processes will become more important if toxic wastes are reduced or become unavailable in the system. If, or when, this occurs, a detrimental effect of this reservation request will be that the high flows necessary for channel maintenance were not requested and they will be available for out-of-stream uses. This may be a future environmental detriment to the fish and wildlife resources which depend on these habitat-building processes to occur, and which will not occur if high flows are annually depleted for other purposes.

Conversely, granting of the full request will be an environmental benefit to fish and wildlife because they will have use of streamflows which could otherwise be diverted for other beneficial uses. In those instances where streams are low at times due to current water withdrawals, establishment of flows will protect the aquatic resource from further degradation.

From an economic standpoint, granting of the reservation in full will contribute to the area economy by increasing the dollars spent on fishing trips, equipment, and recreational activities. This will occur because the Clark Fork, improved by an adequate water supply instream and mine waste reclamation, will attract more fisherman and recreationists than it presently does. These new users will bring additional dollars into the communities along the stream and, in turn, to the state as a whole.

Thus, in weighing the beneficial against the detrimental effects of this alternative on fish and wildlife, the net effect will significantly benefit the aquatic resource. In some instances, water will be available above our flow requests for other uses, and in all cases excess water will be available during the high flow period for direct diversionary uses or offstream storage for late-season use.

Existing water rights in the river basin will at all times be honored. If the reservations requested are not granted and approved, any waters available over and above such existing rights will be vulnerable to future appropriations by permit. If these future appropriations are allowed to be executed in advance of, or without, the reservations requested being established, the fish and wildlife resources will be permaently deprived of the waters necessary for their healthy survival. It is apparent that, under our current laws and regulations, water once appropriated might never again be available for reservation for fish and wildlife purposes. The need for an adequate reservation now is clearly indicated.

(3) DFWP reservations granted in some lesser amounts.

There are many possibilities under this alternative and it is possible only to address them in a general way.

Under this alternative, it can generally be stated that the more the requested flows are discounted, the more detrimental the long term impacts will be on fish, wildlife and public recreation. For purposes of this analysis, it is assumed that the instream flow reservations would be granted at the low level of aquatic habitat potential.

The granting of an instream reservation at less than the full amount requested would not adversely impact existing fish populations in some tributary and mainstem reaches of the Clark Fork. This is due to the fact that these populations are already depressed as a result of the severity of present summer flow depletions and other environmental problems. For example, existing August flows in portions of Clark Fork Reaches #1, 2, and 3 are less than the flows requested at the low level of aquatic habitat potential about 20% of the time, indicating the severity of the present dewatering problem. Granting a reservation at the low level of aquatic habitat potential would continue to maintain populations at their present depressed levels; however, the potential for rehabilitation of the aquatic community would be limited by such action. At the low level of aquatic habitat potential, the best that future rehabilitation efforts could achieve is the establishment of a poor sport fishery - a condition equal to, or only somewhat better than, what presently exists in many reaches.

Whether the sport fishery of a particular stream is classified as poor, fair, good or excellent is a subjective judgement that reflects a number of factors, including the biases and expectations of those making the determinations. An important factor that should play a key role in any classification is the magnitude of the existing fish population as compared to populations in area streams of similar size and type. More fish should mean higher catch rates for fishermen, a consideration that should have substantial bearing on the quality of a fishing experience and greatly influence the outcome of any classification. A logical assumption is that a poor sport fishery (i.e., low catch rates) and low fish abundance go hand-in-hand. For our purposes, a "poor" stream sport fishery is one in which the fish population exists at a level substantially less than the level that typically exists in streams of similar size and type. In addition, a population that exists at a level far below the stream's potential is also defined as supporting a poor sport fishery. Poor stream fisheries normally reflect man-caused influences, such as stream dewatering and pollution, although natural phenomena can also be responsible.

The low inflection point flows derived from the wetted perimeter inflection point method were previously described as providing a poor sport fishery due to their probable impacts on game fish populations. The magnitude of this impact is unquantifiable due to the complexity of factors, both physical and biological, that interact to regulate fish abundance within a given stream. While streamflow is often considered the most influential factor, its impact can be moderated or magnified by the interaction of the other factors such as water temperature, pollution, and the physical habitat available. No two stream populations are expected to respond equally to a fixed flow change.

The only realistic means of quantifying the exact response of a given stream population to a minimum flow established at the low inflection point (or any point) is to collect long-term fish population data at a wide range of different flows and determine the fish-flow relationship. From this relationship, the response can be predicted in quantitative terms.

Such fish-flow relationships have been developed for only a few streams in Montana--the most useful for this discussion being the West Gallatin River (Nelson 1984). From this relationship, it was determined that a minimum summer flow of about 400 cfs was required to maintain the West Gallatin's trout population at an acceptable (but not an optimal) level and, therefore, it was the recommended instream flow. The wetted perimeter inflection point method established a low inflection point at 100 cfs. From the derived fish-flow relationship, 400 cfs would support an adult trout population of about 235 fish per 1,000 ft of stream. At 100 cfs, a population of about 35 adults was predicted, a reduction of 85%. While not all streams are expected to show a loss of this magnitude, such losses can occur and will have a significant impact on the quality of the sport fishing experience. In the case of the West Gallatin River, a poor sport fishery is assured at a low inflection point flow of 100 cfs.

A reservation at the low level of aquatic habitat potential would degrade the fisheries in those tributary and mainstem reaches (such as the headwaters of most tributaries and Reach #4 of the mainstem) that presently do not suffer from severe summer dewatering. For these stream reaches, it is fair to state that the more the full request is discounted, the more the risk of irretrievable loss to the fish and wildlife resource in years to come - especially if such discounting would accommodate applications for new diversionary water uses.

7. State and Federal Legislation and Policies Which Support the Reservation

The rivers and streams of this nation are a valued resource. They have nourished our growth, irrigated our farms, provided electric power and served as avenues of commerce. In places, they provide abundant fish and wildlife habitat and support substantial recreational use. However, many rivers have become degraded by pollution, physical destruction and dewatering. Many became so degraded that they became unfit for human contact. This trend has been slowed by legislation which provides for environmental protection, water pollution abatement and water allocation.

Montana has been more fortunate than most other areas of the country in efforts to maintain its river and stream resources. In general, stress on river resources associated with high population densities and extensive industrial activity has been much less than in other states. In addition, Montana has a legacy of over 20 years of state legislation and policies which promote efforts to prevent or eliminate damage to the physical environment of streams and the quality and quantity of their waters. In fact, some of the earliest environmental legislation (Stream Protection Act of 1963) addressed the physical integrity of stream channels.

Not all of Montana's streams, however, have escaped damage and degradation from man's activities. The upper Clark Fork River is our most notable example of severe, long-term environmental degradation from man's activities. For over 70 years, untreated wastes from one of the world's largest mining ventures were dumped into the upper Clark Fork. Until recently, aquatic life was all but absent in the upper reaches. Fish populations and water quality are still seriously affected by the residue from past mining in the Clark Fork headwaters.

Since the early 1970's, there has been increasing awareness, both on the state and national level, of the necessity to clean up and reclaim sites which contain hazardous wastes. The upper Clark Fork contains no less than three sites which qualify for inclusion under the "Comprehensive Environmental Response Compensation and Liability Act of 1980," commonly referred to as "Superfund." These sites are the direct result of past mining and smelting activities in the Clark Fork headwaters.

Studies are currently underway in the upper Clark Fork basin to identify the nature and extent of the problems and develop appropriate solutions. This application for an instream flow reservation will compliment the existing effort to develop reclamation procedures and will provide the opportunity for enhancing fish populations and recreational opportunities if reclamation efforts are successful.

The importance of the fish and wildlife resource is recognized in the Montana Constitution and in Montana statutes. While this recognition was implicitly recognized before the early 1970's, it has been directly stated since that time. In all this legislation, the fish, wildlife and recreational resource is acknowledged as a legal contender for the land and water that now sustains it. This recognition is gained through constant emphasis on its right to exist and its ability to indicate the quality of our own existence.

The following is a summary and discussion of state and federal legislation and policies relating to this reservation application and to the reclamation of the upper Clark Fork River.

a. State of Montana Legislation and Policies

(1) Constitution of the state of Montana adopted March 22, 1972 and ratified June 6, 1972.

Article IX deals with the environment and natural resources. Section 1(1) states that the state and each person shall maintain and improve a clean and healthful environment in Montana for present and future generations. Section 1(2) states that the legislature shall provide for the administration and enforcement of this duty; Section 1(3) states the legislature shall provide adequate remedies for the protection of the environmental life support system from degradation and provide adequate remedies to prevent unreasonable depletion and degradation of natural resources.

Section 3(3) states that surface waters are the property of the state for the use of its people and are subject to appropriation for beneficial uses as provided by law. This section recognizes the proprietary interest of the state in its water resources. Since fish and wildlife are an inseparable part of these water resources, a water reservation system which provides for their protection is an integral part of the state's ownership responsibilities.

This constitutional mandate and declaration directly support this reservation application because instream uses are beneficial water uses as defined in the 1973 Montana Water Use Act. Granting of the water quantities requested in this application would contribute to maintenance of a clean and healthful environment and would help prevent further depletion and degradation of the natural resources of the upper Clark Fork drainage.

(2) The Montana Water Use Act
(Section 85-2-101 et seq., MCA)

The 1973 law is the authority under which this reservation application is submitted. Section 85-2-101 (2) declares that the purpose of the Act is to implement Article IX, Section 3(4) of the 1972 Montana Constitution. Section 85-2-101 (3) declares that it is the policy of the state to "encourage the wise use of the state's water resources by making them available for appropriation consistent with this act, and to provide for the wise utilization, development, and conservation of the waters of the state for the maximum benefit of its people with the least possible degradation of the natural aquatic ecosystems." (Emphasis added.) Section 85-2-102 defines "beneficial" water use to include fish and wildlife and recreational uses. "Appropriate" is defined to include reservation of water by a public agency. Section 85-2-316 states that a state agency can reserve water "for existing or future beneficial uses, or to maintain a minimum flow, level or quality of water throughout the year, or at such periods, or for such length of time as the board (Board of Natural Resources) designates."

Since this state law is the authority for this reservation, it directly relates to and supports the beneficial use applied for.

(3) Montana Environmental Policy Act
(Section 75-1-101 et seq., MCA)

In section 2 of the Act, the purpose is cited:

"The purpose of this Act, is to declare a state policy which will encourage productive and enjoyable harmony between man and his environment; to promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man; to enrich the understanding of the ecological systems and natural resources important to the state; and to establish an environmental quality council."

The manner in which this policy will be implemented is stated later in the act. Sections 3(a) and 3(b) state:

"(a) In order to carry out the policy set forth in this act, it is the continuing responsibility of the state of Montana to use all practicable means, consistent with other essential considerations of state policy, to improve and coordinate state plans, functions, program, and resources to the end that the state may--

(1) fulfill the responsibilities of each generation as trustee of the environment for succeeding generations;

(2) assure for all Montanans safe, healthful, productive, esthetically and culturally pleasing surroundings;

(3) attain the widest range of beneficial uses of the environment without degradation, risk to health or safety, or other undesirable and unintended consequences;

(4) preserve important historic, cultural, and natural aspects of our unique heritage, and maintain, wherever possible, an environment which supports diversity and variety of individual choice;

(5) achieve a balance between population and resource use which will permit high standards of living and a wide sharing of life's amenities; and

(6) enhance the quality of renewable resources and approach the maximum attainable recycling of depletable resources.

(b) The legislative assembly recognizes that each person shall be entitled to a healthful environment and that each person has a responsibility to contribute to the preservation and enhancement of the environment."

Further, Section 4 states in part:

"The legislative assembly authorizes and directs that, to the fullest extent possible:

(a) The policies, regulations, and laws of the state shall be interpreted and administered in accordance with the policies set forth in this act, and..."

Water allocation is a significant action which falls within the requirements of this act. The legislation directly supports this reservation request which is intended to preserve the ecological integrity of the Clark Fork River and its tributaries and which will contribute to the health and welfare of man and promote harmony between man and his environment.

(4) Mined Land Reclamation Act
(Section 82-4-301 et seq., MCA)

The act controls reclamation of mined lands and gives as one of the purposes of the act (Section 82-4-301) to provide for (1) "the recognition of the recreational and aesthetic values of land as a benefit to the state of Montana" and (2) "that the usefulness, productivity and scenic values of all lands and surface waters involved in mining and mining exploration within the boundaries and lawful jurisdiction of the state will receive the greatest reasonable degree of protection and reclamation to beneficial use."

(5) Governor Schwinden, by Executive Order 10-84, created the Clark Fork River Advisory Council to identify Clark Fork Basin water issues, to prioritize data needs, to identify water management alternatives, and to develop a study plan for a project to establish a comprehensive water quality data base for the Clark Fork River Basin. The goal of the Council and its related project is "to provide administrative continuity to past, current, and planned water-related problems within the basin and will provide state, federal, and local decision-makers with a framework for problem resolution."

(6) Montana Stream Protection Act of 1965
(Section 87-5-501 et seq., MCA)

Section 87-5-501 states it is "the policy of the state of Montana that its fish and wildlife resources and particularly the fishing waters within the state are to be protected and preserved to the end that they are available for all time, without change, in their natural existing state except as may be necessary and appropriate after due consideration of all factors involved."

Although this Act speaks specifically to physical changes in stream channels due to construction or hydraulic projects which alter the existing state of those stream channels, it is obvious that the intent of the act was to protect Montana streams, and the resources they support, from degradation. Water quantity is a necessary factor in maintenance of these streams and cannot be separated from the total habitat requirements which support the fishery resource. Thus this legislation relates to and supports the purpose of this reservation application for beneficial water use.

(7) The Natural Streambed and Land Preservation Act of 1975 (Sections 75-7-101 et seq., MCA)

Section 75-7-102 states "It is the policy of the state of Montana that its natural rivers and streams and the lands and property immediately adjacent to them within the state are to be protected and preserved to be available in their natural, or existing state, and to..." and "further it is the policy of this state...to protect the use of water for any useful or beneficial purpose as guaranteed by the Constitution of the state of Montana."

Instream water uses for fish and wildlife and recreation are beneficial water uses according to the 1973 Montana Water Use Act and are thus subject to appropriation under terms of the 1972 Constitution. Thus this act supports the purpose of this reservation application for beneficial instream water use.

(8) Chapter 345, Laws of 1969 Amending Section 89-801, R.C.M. 1947

This act amended Section 89-801 to allow the Department of Fish and Game to appropriate the unappropriated waters on 12 designated streams or stream sections "in such amounts only as may be necessary to maintain streamflows necessary for the preservation of fish and wildlife habitat." These rights have priority over other water uses in the stream until the district court in the area should decide another beneficial use to be more appropriate. The 12 streams designated included seven which are designated "blue ribbon" plus five others which are important trout fisheries in Montana.

The fact that the legislature so acted before fish, wildlife and recreation were statutorily identified as "beneficial uses" is indicative of the importance placed on instream water uses even before the 1973 Montana Water Use Act was passed. Although Section 89-801 was repealed by the current act, the water filings on the 12 streams are still valid since "existing rights" are recognized by the current water law as well as Article IX Section

3(1) of the 1972 Montana Constitution. This legislation supports the beneficial water use requested in this application.

(9) The Montana Strip and Underground Mine Siting Act (Section 82-4-101 et seq., MCA)

The policy of this act states in part in Section 82-4-102, that it is the declared policy of this state and its people

"- to maintain and improve the state's clean and healthful environment for present and future generations,

- to protect its environmental life-support system from degradation,
- to prevent unreasonable degradation of its natural resources,
- to restore, enhance, and preserve its scenic, historic, archaeologic, scientific, cultural, and recreational sites,"

by proper control and planning of strip mining activities in Montana, and also preventing certain unique lands from being mined if the land has been defined as having such unique characteristics as (1) "biological productivity, the loss of which would jeopardize certain species of wildlife"... (2) "ecological fragility in the sense that the land, once adversely affected could not return to its former ecological role in the foreseeable future," (3) "ecological importance" such that the land is of such importance to the total ecosystem that even temporary disturbances could precipitate a systemwide reaction of unpredictable nature, (4) "scenic, historic, archaeologic, topographic, geologic...or recreational significance."

(10) Section 85-1-101(5) M.C.A. states that it is one of the policies of the State that "the water resources of the state must be protected and conserved to assure adequate supplies for public recreational purposes and for the conservation of wildlife and aquatic life."

Adequate instream flow reservations in the upper Clark Fork River basin will help ensure that the goals of this policy statement are met.

b. Federal Legislation

(1) Federal Water Pollution Control Act of 1956 (Public Law 84-660) with amendments of 1961, 1965, 1966; the Water Quality Improvement Act of 1970 and the Water Pollution Control Act Amendments of 1972 (Public Law 92-500).

Through these acts, water pollution control laws were strengthened. Public Law 92-500, the latest act, has the objective "to restore and maintain the chemical, physical and biological integrity of the nation's waters." Whenever possible, water quality is to be suitable for recreational contact and for protection and propagation of fish and wildife. The 1965 amendment to the act was termed the "Water Quality Act of 1965" and gave the states the opportunity to hold public hearings and establish water quality standards for interstate and coastal waters within their borders.

Subsequent to Public Law 92-500 federal regulations were published to implement the law. Federal regulation CFR 40 E 130.17 required revisions to state water quality standards which would protect water quality for a number of uses, including propagation of fish, shellfish, and wildlife and for recreation purposes. The regulations also directed the states to develop and adopt a statewide antidegradation policy which would provide that existing instream water uses be maintained and protected. No further water quality degradation which would adversely affect existing instream water uses would be allowed. Also, high quality waters which exceed water quality levels necessary to support propagation of fish, shellfish and wildlife, and recreation shall be maintained and protected unless the public should decide otherwise.

This legislation directly relates to this reservation application in that water quality would be protected from degradation, propagation of fish and wildlife would be sustained, and public use of the waters for recreational purposes would be provided.

(2) The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) 42 U.S.C. and 9601 et seq., was passed to facilitate the removal of hazardous wastes from "...the navigable waters..., any other surface water, ground water, drinking water supply, land surface or subsurface strata, or ambient air within the United States"...42 U.S.C. 9601(8). CERCLA includes the establishment of the Hazardous Substance Response Trust Fund (i.e. Superfund), 42 U.S.C. § 9611 to provide for the costs of governmental response to hazardous waste cleanup.

Pursuant to this and other federal legislation, the United States Environmental Protection Agency has designated the Silver Bow Creek complex, which includes the headwaters of the Clark Fork River, the Anaconda Smelter site and Milltown dam and reservoir as study sites for potential cleanup under the Hazardous Substance Response Trust Fund.

The effort currently being expended to identify, study and develop a reclamation plan for the chronic pollution problems of the upper Clark Fork basin certainly supports the need for protection of the existing flow conditions through establishment of an instream flow reservation.

(3) The National Environmental Policy Act of 1969 (Public Law 91-190; 83 Stat. 852)

Section 2 of the Act states the purpose is "to declare a national policy which will encourage productive and enjoyable harmony between man and his environment and biosphere and stimulate the health and welfare of man; to enrich the understanding of the ecological systems and national resources important to the nation; and to establish a Council on Environmental Quality."

The upper Clark Fork River has the potential to become a first-class fishery throughout its length if the problems of water depletion and toxic metals contamination can be solved. Portions of the stream already provide an excellent fishery. The eventual enhancement of this important ecological system through the granting of this reservation request will allow productive and enjoyable harmony between man and the river, will help prevent further damage to this river environment, and will stimulate the health and welfare of man. This reservation request for beneficial water use is supported by this legislation.

(4) Federal Aid in Fish Restoration Act (Dingell-Johnson Act) (64 Stat. 430, as amended; 16 U.S.C. 777-777k)

An Act "to provide that the United States shall aid the states in fish restoration and management projects and for other purposes."

This act provides an excise tax on sport fishing equipment and supplies purchased by fishermen in each state. The money collected is apportioned back to each state under terms of a formula based on area of state and number of fishing licenses sold. These funds are available annually and are used by state fish and game departments for fish restoration and management projects for all fish species which have material value in connection with sport or recreation in fresh (and marine where applicable) waters of the United States. This act enables the sportsmen who utilize fish resources to pay their own way toward fisheries preservation and management. Since this act became effective on August 9, 1950, sportsmen have realized the importance of maintaining fish habitat and have funded this program through their purchase of sport fishing equipment. The maintenance of this fish habitat is directly related to water quantity and thus this reservation request is directly related to continuation of this important wildlife conservation program.

Note: In 1984, the Wallop-Breaux Trust Fund (also called Aquatic Resources Trust Fund) was enacted as part of H.R. 4170, the Deficit Reduction Act. This legislation expanded the sources of revenue available to states for fish restoration and management programs (through the Dingle-Johnson Act) by adding additional fishing equipment and supplies to those already excise-taxed. In addition, the federal excise taxes imposed on fuels used for recreational boating were transferred to the fund, as were import duties on sport fishing equipment and pleasure boats and yachts. This legislation provides further evidence that the sportsmen who utilize the fisheries resources are willing to pay their own way to maintain and enhance these valuable resources.

(5) Federal Aid in Wildlife Restoration Act (Pittman-Robertson Act) (50 Stat. 917, as amended; 16 U.S.C. 669-669b, 669c-669i)

This act, passed on September 2, 1937 authorized the collection of an excise tax on sport hunting equipment, such as firearms and ammunition, portions of which are returned to the states for programs on the research and management of wildlife species, including big game, small game, waterfowl and furbearers. The funds are returned to state fish and game departments under terms of a formula based on area of the state and number of hunting licenses sold. This act enables the sportsmen who utilize wildlife resources to pay their own way toward wildlife preservation and management. Since this act became effective, sportsmen have realized the importance of maintaining wildlife habitat in producing huntable wildlife populations and have funded this program through their purchase of sport hunting equipment and supplies. The maintenance of riparian wildlife habitat is directly related to water quantity and this reservation request is directly related to continuation of this important wildlife conservation program.

(6) Fish and Wildlife Coordination Act (48 Stat. 401 as amended; 16 U.S.C. 661 et seq.)

This act was passed on March 10, 1934 and last amended in 1958. The purpose of the act is to recognize "the vital contribution of our wildlife resources to the nation, the increasing public interest and significance thereof due to expansion of our national economy and other factors, and to provide that wildlife conservation shall receive equal consideration and be coordinated with other features of water resource-development programs through the effectual and harmonious planning, development, maintenance, and coordination of wildlife conservation and rehabilitation..." One of the provisions of the act authorized the Secretary of Interior to "provide assistance to, and cooperate with, federal, state and public or private agencies and organizations in the development, protection, rearing, and stocking of all species of wildlife, resources thereof, and their habitat..." (Emphasis added.) The Act has been important in water development projects and proposals by inclusion of fish and wildlife needs and values in any of these projects authorized for construction. Many acres of wildlife habitat have been acquired for inclusion in irrigation and hydropower projects which otherwise would not have been available for wildlife management today.

The act points out the need for orderly water resource development which specifically includes preservation of fish and wildlife habitat, such habitat being, in many cases, directly related to adequate water quantity such as is requested in this reservation application.

In summary, it seems quite clear that state and federal policymaking bodies have great concern for the preservation of the environment and have mandated that such natural resources as water and fish and wildlife be protected for continued health and enjoyment. These laws and policies are submitted in support of this reservation request to help in the preservation of the fish and wildlife resources themselves as well as the recreational values these resources bring to the people of Montana and the nation.

VII.

SUMMARY

The DFWP is applying for instream flow reservations in the upper Clark Fork River and selected tributaries. The purpose is to preserve the existing aquatic and riparian ecosystems and associated recreational values. They will also provide the opportunity to enhance fish populations and expand recreational opportunities in the future when reclamation efforts are initiated and chronic pollution problems lessened. A portion of the instream reservations for selected tributaries is intended to prevent further deterioration of the water quality of the mainstem Clark Fork during the winter months.

Maintaining adequate instream flows is essential because the upper Clark Fork drainage has been severely impacted by past mining activities, and flows are often depleted by agricultural water withdrawals during the low flow summer months. Adequate instream flows dilute toxic metal concentrations generated by mining and smelting activities and provide habitat for fish populations of high recreational value. Adequate flows also help preserve breeding populations of two fish species of special concern (e.g., bull trout and cutthroat trout) which have been eliminated or greatly reduced in number over much of their former range.

Based on the collection and analyses of biological data and hydrological parameters within the upper Clark Fork drainage, instream flow values have been derived which would sustain as well as allow eventual enhancement of the aquatic and streamside environment. These instream flow values were derived for various reaches of the Clark Fork and certain tributary streams which have critical importance to the ecological integrity of the drainage as a whole. Refer to Table 11 for a summary of the requested flows for these streams.

Reservations of instream flows are additionally requested for certain tributary streams during the low flow winter period (January 1 through April 30) to prevent further water quality degradation. During the low flow winter period, copper which originates upstream of Warm Springs Creek, and enters the Clark Fork, routinely exceeds water quality standards. Tributary inflow during this period is vital for dilution of copper concentrations and to help prevent frequent and high level exceedances of copper criteria in the mainstem. Therefore, it is recommended that all of the base flow in certain Clark Fork tributary streams be reserved for instream purposes during the low flow winter period (see Table 11).

The naturally occurring high spring flows are an important part of stream ecology. The spring flows transport sediment and bedload material and serve to maintain channel form and processes. The streambanks and adjacent floodplain of the upper Clark Fork, however, contain substantial deposits of mine tailings. These tailings contain, among other things, high concentrations of copper and are a source of chronic pollution to the upper Clark Fork.

High flows in the upper Clark Fork cause an increase in copper levels by eroding into streambank tailing deposits, and by flooding the riparian areas where tailings have historically been deposited. Therefore, an instream reservation for a portion of the high spring flows is not requested. The other reason a high flow is not requested is because of Section (5) of 85-2-316, MCA which states that:

> "The board shall limit any reservations after May 9, 1979, for maintenance of minimum flow, level, or quality of water that it awards at any point on a stream or river to a maximum of 50% of the average annual flow of record on gauged streams. Ungauged streams can be allocated at the discretion of the board."

Since most of the annual flow volume occurs during spring runoff, a flow request for this period would not be compatible with this section of Montana law.

The mean annual discharge of certain gauged streams in the upper Clark Fork basin is compared with the instream flows requested for those streams in Table 20. No gauge records are available for the other streams listed, with the exception of Warm Springs Creek which has only two years of record as of the 1985 water year. The USGS requires at least five years of record to determine mean annual flow.

Water availability for additional consumptive use in the upper Clark Fork River and several of its major tributaries is very limited. Existing agricultural water use seriously depletes the lower reaches of many major tributaries during the irrigation season. Portions of the mainstem of the upper Clark Fork also suffer serious dewatering during below average water years. Establishment of an instream flow reservation combined with existing depleted flow conditions will further limit water availability for future consumptive use. However, an instream flow reservation will prevent water availability problems of existing users from becoming more severe or occurring more frequently. The lack of a large instream flow reservation for the spring high flow period does allow for future storage projects which can store a portion of the high spring flow for use at other times.

Table 20. Instream flows requested and average annual flow of record (where available) for the upper Clark Fork River and tributary streams.

Stream	Instream Flow Requested (cfs)	Instream Flow Requested (acre-feet)	Average Annual Flow[1] (cfs)	Average Annual Flow[1] (acre-feet)	USGS Gauge Station No.	Years of Record
Clark Fork-Reach #1	180	130,314	343	248,500	12-324200	7
Clark Fork-Reach #2	400	289,587	677	490,500	12-324680	8
Clark Fork-Reach #3	500	361,983	1,021	739,700	12-331900	6
Clark Fork-Reach #4	600	434,380	1,407	1,015,000	12-340500 minus	56
					12-340000[2]	49
Warm Springs Cr.-Reach #1	50	36,198				
Warm Springs Cr.-Reach #2	40	28,959				
Barker Creek	12	8,688				
Cable Creek	10	7,240				
Storm Lake Creek	10	7,240				
Twin Lakes Creek	13	9,412				
Lost Creek	16	11,583				
Racetrack Creek-Reach #1	26	18,823				
Racetrack Creek-Reach #2	3	2,172	59.1	42,820	12-324100	16
Dempsey Creek	3.5	2,534				
Little Blackfoot R.-Reach #1	17	12,307				
Little Blackfoot R.-Reach #2	85	61,537	182	131,900	12-324590	13
Snowshoe Creek	9	6,516				
Dog Creek	9	6,516				
Gold Creek	34	24,615				
Flint Creek-Reach #1	50	36,198	30.3	21,950	12-325500	45
Flint Creek-Reach #2	45	32,578	102	73,900	12-329500	44
Boulder Creek	20	14,479	48.4	35,070	12-330000	46
N. Fk. Flint Creek	6	4,344				
Stuart Mill Creek	14	10,135				
Harvey Creek	3	2,172				

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[1] Data from USGS Surface Water Records for Montana through water year 1985.

[2] Station 12-340000 (Blackfoot R. near Bonner - 1,636 cfs; 1,185,000 A.F./yr; 49-yr. record
Station 12-340500 (Clark Fork R. above Missoula - 3,037 cfs; 2,200,000 A.F./yr; 56-yr. record

VIII.

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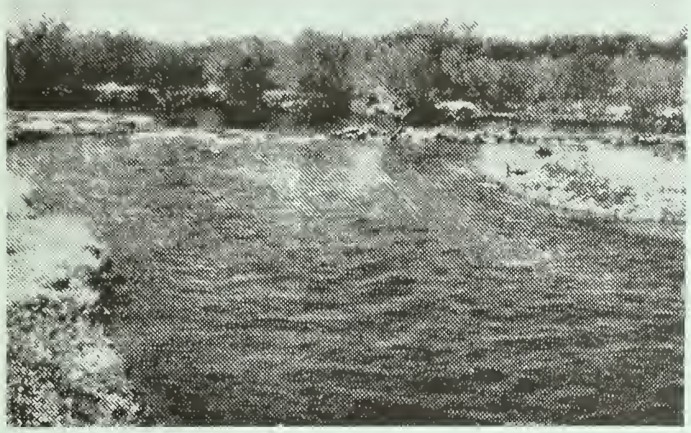
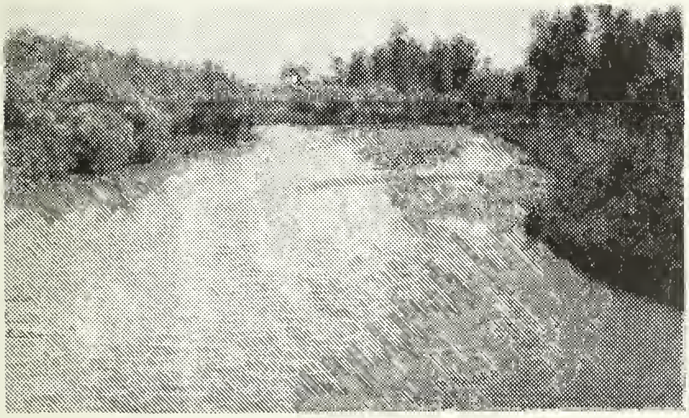


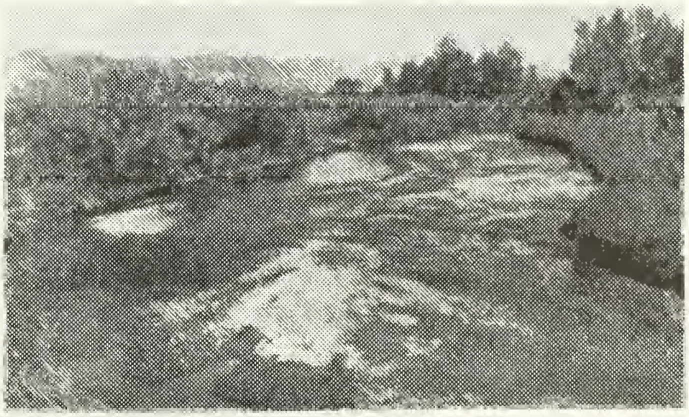
ADDENDA

ADDENDUM A

WATER AVAILABILITY DATA FOR THE UPPER CLARK FORK RIVER AND SELECTED TRIBUTARIES

1 - HISTORIC AND RECONSTITUTED STREAMFLOW
2 - WATER AVAILABLE IN EXCESS OF HIGH AND
    LOW INFLECTION POINT FLOWS





ADDENDUM A

This addendum presents historic (measured) and reconstituted (estimated) streamflow data, and amount of water available in excess of high and low inflection point flows for the upper Clark Fork River and selected tributaries. The periods of USGS-recorded streamflow are presented and the methods used to reconstitute data are described. The information was prepared by Steve Holnbeck, Hydrologist, Montana Department of Natural Resources and Conservation and Chuck Parrett, Hydrologist, U.S. Geological Survey, Helena, Montana.

HEC-4 RECONSTITUTED AND HISTORIC DATA BY USGS

Gage Location	Hec-4	USGS Recorded
Clark Fork above Missoula	--	Oct. 1950- Sept. 1982
Blackfoot River near Bonner	--	Oct. 1950- Sept. 1982
Rock Creek near Clinton	Oct. 1950- Sept. 1972	Oct. 1972- Sept. 1982
Clark Fork near Clinton	See * below	June 1979- Sept. 1982
Clark Fork at Drummond	Oct. 1950- Sept. 1972	Oct. 1972- Sept. 1982
Little Blackfoot River	Oct. 1950- Sept. 1972	Oct. 1972- Sept. 1982
Clark Fork near Gold Creek	See * below	Oct. 1977- Sept. 1982
Clark Fork at Deer Lodge	See * below	Oct. 1978- Sept. 1982
Racetrack Creek	Oct. 1950- July 1957 Oct. 1973- Sept. 1982	Aug. 1957- Sept. 1973

* Missing record for three sites on Clark Fork were accomplished as follows:

*Clark Fork near Clinton (Oct. 1950 - May 1979)

$$Q_{CLINT} = \text{CF @ Missoula} - \text{Blackfoot} - \text{Rock Cr.} \times f$$

where (f) is a monthly calibration coefficient derived from the few years of historic data at Clinton related to

concurrent data at Missoula gage, Blackfoot gage, and Rock Creek gage.

*Clark Fork near Gold Creek (Oct. 1950 - Sept. 1977)

$$Q_{GOLD} = Q_{DRUM} \times {}^{f}J$$

where (${}^{f}J$) is a monthly constant or coefficient derived from concurrent historic data at Gold Creek and Drummond for each month J.

*Clark Fork at Deer Lodge (Oct. 1950 - Sept. 1978)

$$Q_{DEER} = Q_{DRUM} \times {}^{a}J$$

where (${}^{a}J$) is a monthly coefficient derived as in the case of Clark Fork near Gold Creek.

Stations Developed through Simple Accounting Procedures

*Clark Fork near Turah

$$Q_{TURAH} = Q_{MISSOULA} - Q_{BLACKFOOT}$$

*Clark Fork at Garrison

$$Q_{GARR} = Q_{DEER} + Q_{LITTLE\ BLACKFOOT}$$

307/15

CLARK FORK WATER AVAILABILITY STUDY
CLARK FORK AT DEER LODGE
(FLOW IN CFS)

		OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOT
Reconstituted	1951	359.0	354.2	311.5	274.5	456.3	385.5	682.6	879.3	421.5	451.8	205.0	275.5	5057.0
	1952	424.4	353.7	231.3	297.5	232.5	349.6	564.6	750.0	471.9	160.0	107.8	240.2	4254.2
	1953	221.9	241.0	218.9	250.0	274.4	263.6	272.6	431.4	1290.0	218.5	141.0	184.8	4028.1
	1954	204.2	256.7	206.4	224.5	324.3	292.6	399.7	374.7	447.8	246.2	145.6	183.5	3306.2
	1955	270.0	264.0	229.4	223.0	190.9	247.0	281.7	261.9	518.8	823.1	221.4	187.7	3719.1
	1956	273.0	271.9	253.0	283.0	244.3	468.7	529.3	318.0	609.6	251.9	124.2	142.9	3769.3
	1957	268.3	288.0	242.9	203.0	305.0	336.3	298.1	593.7	273.0	100.7	69.7	161.7	3140.3
	1958	211.1	250.7	232.1	204.0	207.5	286.6	345.6	748.8	210.5	204.4	115.6	187.7	3174.6
	1959	246.8	327.5	263.5	319.0	254.8	436.5	483.8	211.8	801.4	193.4	133.2	214.2	3836.1
	1960	547.0	493.0	427.7	339.0	318.8	452.6	464.1	379.8	624.2	99.2	35.7	199.5	4420.6
	1961	224.9	256.7	217.0	213.0	280.6	259.9	221.8	360.9	298.5	77.9	52.5	127.7	2591.3
	1962	249.8	262.7	209.3	211.0	247.0	296.2	509.2	660.9	567.1	333.3	137.4	203.3	3892.7
	1963	350.0	353.3	295.7	231.0	471.5	345.9	283.3	453.6	721.8	223.1	96.9	216.7	4032.8
	1964	271.8	252.5	257.3	219.5	213.4	249.8	322.7	472.3	1139.7	330.6	216.9	287.7	4304.1
	1965	310.0	311.9	286.6	331.5	393.8	339.9	509.6	710.1	944.5	320.7	234.1	433.9	5176.6
	1966	371.5	330.9	340.3	305.0	282.0	330.3	326.4	504.9	284.2	103.0	78.7	124.7	3432.9
	1967	216.3	246.1	240.0	234.5	264.0	313.7	328.0	437.5	894.9	359.5	152.5	166.7	3903.8
	1968	331.5	351.0	230.3	300.0	426.9	441.6	245.2	437.1	332.7	172.5	139.0	321.7	4279.5
	1969	365.5	361.1	434.9	329.5	270.0	421.4	780.2	734.1	210.1	654.7	159.1	238.1	5003.7
	1970	301.0	304.1	326.4	230.0	240.1	281.5	262.0	453.1	503.2	315.4	174.2	298.2	3694.2
	1971	267.9	316.9	274.1	318.5	613.6	297.2	351.8	750.0	640.9	122.7	140.2	193.2	4292.1
	1972	265.3	302.7	211.7	240.5	203.8	586.0	391.1	466.5	749.7	228.0	131.2	264.6	4091.1
	1973	255.4	276.0	226.1	252.5	227.2	261.3	208.7	99.0	95.2	44.8	34.4	110.0	2090.7
	1974	165.1	240.6	199.7	410.5	219.0	323.4	364.5	284.1	556.2	167.2	122.6	145.7	3193.6
	1975	218.9	254.4	229.4	199.5	190.9	281.1	338.7	828.6	1553.5	947.3	509.6	403.6	5955.5
	1976	507.0	500.9	573.1	490.0	398.8	487.1	737.2	1038.3	793.6	416.1	330.5	336.8	6609.4
	1977	344.4	331.7	287.5	229.0	289.8	263.6	243.5	112.8	111.9	73.3	57.4	130.6	2479.5
Historic	1978	233.5	237.4	252.5	231.0	232.8	417.2	408.4	453.0	511.4	429.0	164.4	327.6	3898.1
	1979	308.0	285.0	261.0	228.0	308.0	387.0	353.0	446.0	276.0	111.0	95.5	123.0	3186.5
	1980	204.0	236.0	234.0	208.0	262.0	309.0	352.0	719.0	1151.0	468.0	135.0	295.0	4573.0
	1981	370.0	384.0	353.0	311.0	298.0	299.0	362.0	971.0	899.0	263.0	120.0	181.0	4811.0
	1982	298.0	332.0	302.0	266.0	481.0	366.0	422.0	701.0	1106.0	593.0	130.0	253.0	5256.0
	AVERAGE	295.5	308.4	279.5	268.7	302.0	346.2	395.1	534.9	642.5	297.1	151.6	225.8	4047.3
	MEDIAN	271.8	302.7	261.0	250.0	280.6	330.3	353.0	487.5	624.2	246.2	137.4	208.3	4028.1
	80 PERCENTILE	221.9	252.5	218.9	219.5	227.2	281.1	281.7	360.9	284.2	111.0	36.9	145.7	3198.6
	60 PERCENTILE	265.3	271.9	242.9	231.0	254.8	299.0	333.7	453.0	518.3	204.4	124.2	187.7	3886.1
	40 PERCENTILE	301.0	316.9	230.3	283.0	294.4	345.9	391.1	593.7	749.7	315.4	141.0	240.2	4254.2
	20 PERCENTILE	365.5	353.7	326.4	319.0	393.8	436.5	509.2	748.8	944.5	429.0	151.2	298.2	4811.0
	MAXIMUM	547.0	500.9	573.1	490.0	613.6	586.0	780.2	1038.3	1553.5	947.3	509.6	433.9	6609.4
	MINIMUM	165.1	236.0	199.7	199.5	190.9	247.0	208.7	99.0	95.2	44.3	34.4	110.0	2090.7

Clark Fork River

Historic and reconstituted streamflow (cfs) at Deerlodge, Water Years 1951-1982.

All
Historic

CLARK FORK WATER AVAILABILITY STUDY
LITTLE BLACKFOOT RIVER
(FLOW IN CFS)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOT
1951	80.0	74.0	75.0	61.0	165.0	103.0	228.0	401.0	529.0	113.0	67.0	92.0	1988.0
1952	105.0	73.0	81.0	57.0	69.0	110.0	335.0	799.0	241.0	114.0	36.0	54.0	2074.0
1953	49.0	40.0	43.0	62.0	54.0	74.0	129.0	746.0	1365.0	208.0	63.0	49.0	2882.0
1954	40.0	42.0	43.0	48.0	82.0	74.0	160.0	568.0	403.0	104.0	37.0	50.0	1651.0
1955	52.0	53.0	43.0	39.0	33.0	48.0	110.0	374.0	518.0	165.0	35.0	68.0	1538.0
1956	67.0	56.0	55.0	56.0	47.0	188.0	304.0	1144.0	339.0	108.0	42.0	73.0	2530.0
1957	55.0	65.0	67.0	45.0	56.0	99.0	161.0	1104.0	368.0	55.0	22.0	44.0	2142.0
1958	54.0	54.0	38.0	43.0	55.0	64.0	119.0	595.0	402.0	72.0	53.0	70.0	1629.0
1959	59.0	61.0	35.0	64.0	69.0	93.0	233.0	674.0	326.0	134.0	30.0	84.0	2332.0
1960	85.0	45.0	74.0	58.0	60.0	183.0	315.0	820.0	291.0	24.0	39.0	48.0	2042.0
1961	69.0	64.0	51.0	46.0	80.0	66.0	101.0	345.0	296.0	26.0	9.0	35.0	1188.0
1962	39.0	42.0	41.0	37.0	44.0	66.0	243.0	897.0	373.0	166.0	51.0	45.0	2044.0
1963	86.0	82.0	76.0	41.0	229.0	106.0	173.0	229.0	393.0	112.0	40.0	69.0	1636.0
1964	72.0	67.0	44.0	50.0	75.0	45.0	155.0	361.0	992.0	236.0	77.0	78.0	2252.0
1965	57.0	56.0	62.0	83.0	109.0	152.0	277.0	752.0	733.0	173.0	104.0	115.0	2673.0
1966	107.0	39.0	135.0	69.0	113.0	155.0	330.0	992.0	237.0	72.0	26.0	37.0	2362.0
1967	37.0	45.0	46.0	43.0	56.0	75.0	103.0	628.0	1001.0	145.0	45.0	70.0	2299.0
1968	120.0	33.0	57.0	51.0	187.0	190.0	179.0	970.0	391.0	111.0	35.0	104.0	2528.0
1969	110.0	105.0	77.0	61.0	76.0	187.0	463.0	1143.0	362.0	97.0	46.0	63.0	2790.0
1970	59.0	50.0	54.0	50.0	67.0	76.0	222.0	609.0	512.0	209.0	55.0	76.0	2039.0
1971	72.0	72.0	44.0	73.0	176.0	150.0	208.0	595.0	490.0	99.0	39.0	64.0	2082.0
1972	61.0	56.0	51.0	76.0	77.0	256.0	263.0	713.0	862.0	113.0	66.0	76.0	2670.0
1973	60.0	60.0	44.0	46.0	57.0	60.0	89.0	133.0	90.0	24.0	17.0	23.0	703.0
1974	35.0	49.0	43.0	118.0	59.0	120.0	223.0	442.0	475.0	70.0	53.0	45.0	1732.0
1975	51.0	54.0	48.0	45.0	43.0	55.0	107.0	953.0	1803.0	410.0	191.0	108.0	3868.0
1976	129.0	122.0	199.0	135.0	102.0	163.0	486.0	1176.0	518.0	188.0	112.0	86.0	3416.0
1977	86.0	80.0	64.0	48.0	69.0	68.0	116.0	94.0	65.0	35.0	12.0	20.0	757.0
1978	42.0	45.0	55.0	50.0	48.0	209.0	314.0	669.0	402.0	195.0	68.0	95.0	2192.0
1979	75.0	62.0	49.0	50.0	78.0	134.0	247.0	749.0	279.0	72.0	35.0	40.0	1370.0
1980	49.0	55.0	43.0	45.0	55.0	58.0	137.0	746.0	787.0	227.0	79.0	84.0	2415.0
1981	95.0	120.0	150.0	84.0	154.0	130.0	278.0	1460.0	652.0	183.0	68.0	65.0	3439.0
1982	92.0	86.0	75.0	58.0	233.0	145.0	269.0	631.0	710.0	238.0	74.0	71.0	2682.0
AVERAGE	70.3	65.9	66.0	59.4	89.9	115.7	221.9	703.5	554.8	134.0	57.4	65.8	2204.7
MEDIAN	67.0	61.0	55.0	51.0	69.0	110.0	222.0	746.0	475.0	114.0	53.0	69.0	2252.0
80 PERCENTILE	49.0	49.0	43.0	45.0	55.0	66.0	119.0	442.0	296.0	72.0	35.0	45.0	1651.0
60 PERCENTILE	59.0	56.0	49.0	50.0	60.0	76.0	179.0	631.0	393.0	108.0	42.0	64.0	2074.0
40 PERCENTILE	72.0	66.0	62.0	58.0	77.0	134.0	247.0	752.0	518.0	165.0	63.0	71.0	2392.0
20 PERCENTILE	95.0	83.0	77.0	73.0	113.0	133.0	314.0	992.0	826.0	208.0	79.0	84.0	2632.0
MAXIMUM	129.0	122.0	199.0	135.0	233.0	256.0	486.0	1460.0	1803.0	410.0	191.0	115.0	3868.0
MINIMUM	35.0	40.0	38.0	37.0	33.0	45.0	89.0	94.0	65.0	24.0	9.0	20.0	703.0

Little Blackfoot River

Historic streamflow (cfs) near Garrison, Water Years 1951-1982.

All
Reconstituted

CLARK FORK WATER AVAILABILITY STUDY
CLARK FORK AT GARRISON
(FLOW IN CFS)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOT
1951	439.0	428.2	386.5	335.5	621.3	488.5	910.6	1280.3	950.6	564.8	272.0	367.5	7044.9
1952	529.4	425.7	372.8	344.5	321.5	459.6	399.6	1549.0	712.9	274.0	143.8	294.2	6328.2
1953	270.9	281.0	261.9	312.0	348.4	337.6	401.6	1177.4	2655.0	426.5	204.0	233.8	6910.1
1954	244.2	293.7	249.4	272.5	406.3	366.6	559.7	942.7	850.8	350.2	182.6	233.5	4957.2
1955	322.0	317.0	272.4	262.0	223.9	295.0	391.7	635.9	1036.8	988.1	306.4	255.7	5307.1
1956	340.0	327.9	309.0	339.0	291.3	656.7	833.3	1462.0	998.6	359.9	166.2	215.8	6299.8
1957	323.3	354.0	309.9	248.0	361.0	435.3	459.1	1697.7	641.0	155.7	91.7	205.7	5282.3
1958	265.1	304.7	240.1	247.0	262.5	350.6	464.6	1343.8	612.5	276.4	178.6	257.7	4803.6
1959	305.8	388.5	343.5	383.0	323.8	529.5	695.8	885.8	1627.4	327.4	163.2	293.2	6268.1
1960	632.0	528.0	501.7	397.0	378.8	635.6	779.1	1199.8	915.2	123.2	124.7	247.5	6462.6
1961	293.9	320.7	262.0	259.0	360.6	325.9	322.8	705.9	594.5	103.9	61.5	162.7	3779.3
1962	238.8	304.7	250.8	248.0	291.0	362.2	752.2	1557.9	940.1	499.3	138.4	253.3	5836.7
1963	436.0	435.3	371.7	272.0	700.5	451.9	456.3	682.6	1114.8	335.1	126.9	235.7	5618.8
1964	343.8	319.5	301.3	269.5	288.4	294.8	477.7	853.3	2181.7	566.6	293.9	365.7	6556.1
1965	367.0	367.9	348.6	419.5	502.8	491.9	786.6	1462.1	1677.5	493.7	339.1	548.9	7804.6
1966	478.5	469.9	475.0	375.0	395.0	485.3	656.4	1496.9	521.2	175.0	104.7	161.7	5794.9
1967	253.3	291.1	236.0	282.5	320.0	388.7	431.0	1115.5	1895.9	504.5	197.5	236.7	6152.8
1968	451.5	434.0	337.3	351.0	613.9	631.8	424.2	1407.1	1223.7	283.5	224.0	425.7	6807.5
1969	475.5	456.1	511.9	390.5	346.0	608.4	1248.2	1877.1	572.1	741.7	205.1	356.1	7788.7
1970	360.0	354.1	380.4	280.0	307.1	357.5	484.0	1067.1	1015.2	524.4	229.2	374.2	5733.2
1971	339.9	388.9	318.1	391.5	789.6	447.2	559.8	1345.0	1130.9	221.7	179.2	262.2	6374.1
1972	326.3	358.7	262.7	316.5	280.8	842.0	654.1	1179.5	1611.7	341.0	247.2	340.6	6761.1
1973	315.4	336.0	270.1	298.5	284.2	321.3	297.7	232.0	185.2	68.8	51.4	133.0	2793.7
1974	200.1	289.6	242.7	528.5	278.0	443.4	587.5	726.1	1031.2	237.2	175.6	190.7	4930.6
1975	269.9	308.4	277.4	244.5	233.9	336.1	445.7	1781.6	3356.5	1357.3	700.6	511.6	9823.5
1976	636.0	622.9	772.1	625.0	500.8	650.1	1223.2	2214.3	1311.6	604.1	442.5	422.8	10025.4
1977	430.4	411.7	351.5	276.0	358.8	331.6	359.5	206.8	176.9	113.3	69.4	150.6	3236.5
1978	275.5	282.4	307.5	281.0	280.8	626.2	722.4	1122.0	913.4	624.0	232.4	422.6	6090.1
1979	383.0	347.0	310.0	278.0	386.0	521.0	600.0	1195.0	555.0	133.0	130.5	163.0	5056.5
1980	253.0	291.0	277.0	253.0	317.0	367.0	539.0	1465.0	1938.0	695.0	214.0	379.0	6988.0
1981	465.0	504.0	503.0	395.0	452.0	429.0	640.0	2431.0	1531.0	446.0	188.0	246.0	8230.0
1982	390.0	418.0	383.0	324.0	714.0	511.0	691.0	1332.0	1816.0	831.0	204.0	324.0	7938.0
AVERAGE	365.8	374.3	345.6	328.1	391.9	461.8	617.0	1238.4	1197.3	431.1	209.0	291.6	6252.0
MEDIAN	340.0	334.1	310.0	312.0	348.4	447.2	587.5	1332.0	1036.8	359.9	188.4	262.2	6299.8
80 PERCENTILE	270.9	304.7	268.0	262.0	284.2	337.6	431.0	853.3	612.5	183.0	126.9	205.7	5056.5
60 PERCENTILE	322.0	327.9	301.3	280.0	320.0	388.7	484.0	1177.4	940.1	327.4	178.6	247.5	5836.7
40 PERCENTILE	367.0	388.5	348.5	339.0	361.0	485.3	654.1	1407.1	1223.7	493.7	204.0	298.2	6462.6
20 PERCENTILE	465.0	435.3	383.0	391.5	500.8	626.2	779.1	1557.9	1816.0	524.0	247.2	379.0	7788.7
MAXIMUM	636.0	622.9	772.1	625.0	789.6	842.0	1248.2	2431.0	3356.5	1357.3	700.6	548.9	10025.4
MINIMUM	200.1	281.0	240.1	244.5	223.9	294.8	297.7	206.8	176.9	68.8	51.4	133.0	2793.7

Clark Fork River

Reconstituted streamflow (cfs) at Garrison, Water Years 1951-1982.

CLARK FORK WATER AVAILABILITY STUDY
CLARK FORK NEAR GOLD CREEK
(FLOW IN CFS)

		OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOT
Reconstituted	1951	534.5	554.4	486.7	417.2	744.0	636.9	1315.3	2550.0	1029.2	939.3	400.0	446.1	10103.7
	1952	690.9	553.7	456.0	437.0	411.7	577.5	1037.8	2175.0	1152.0	332.6	210.4	389.0	8473.7
	1953	361.2	377.3	342.0	380.0	480.0	435.5	525.3	1251.1	3149.0	454.2	275.2	299.2	8330.0
	1954	332.5	401.3	322.5	341.2	529.7	433.4	770.2	1036.6	1093.1	511.7	234.0	297.2	6457.2
	1955	439.6	413.3	333.5	339.0	311.2	403.1	542.7	759.5	1266.6	1711.1	432.0	304.0	7285.6
	1956	444.5	425.5	395.2	430.2	398.2	774.4	1019.9	922.2	1483.2	523.8	242.4	231.2	7295.8
	1957	436.8	450.7	379.5	308.6	497.2	555.6	574.3	1721.7	666.5	209.3	136.0	261.9	6198.1
	1958	343.7	392.4	315.7	310.1	338.2	473.5	665.0	2171.5	513.8	425.0	225.6	304.0	6479.5
	1959	401.8	512.6	411.7	484.9	415.5	721.2	932.2	614.2	1956.3	402.1	260.0	346.8	7459.4
	1960	890.4	756.0	668.2	515.3	519.7	747.8	894.3	1101.4	1523.9	206.2	167.2	323.0	8313.5
	1961	366.1	401.8	339.0	323.8	457.5	429.4	427.4	1046.6	728.7	161.9	102.4	206.7	4991.3
	1962	406.7	411.1	327.7	320.7	402.7	489.4	981.2	1916.6	1334.4	692.3	268.0	337.3	7938.3
	1963	559.8	553.0	462.0	351.1	768.7	571.5	545.9	1315.4	1762.1	403.7	169.6	350.9	7883.8
	1964	442.4	395.3	402.0	333.6	343.0	412.7	621.7	1427.7	2904.2	687.3	423.2	465.8	8563.9
	1965	504.7	488.2	447.7	503.9	642.0	561.6	932.0	2059.3	2305.7	666.8	554.4	702.4	10418.7
	1966	604.8	596.2	571.7	465.1	459.7	545.7	623.8	1464.2	693.9	214.1	153.6	202.0	6559.8
	1967	352.1	385.2	375.0	350.4	430.5	518.3	632.0	1413.7	2184.6	747.3	297.6	270.0	7962.8
	1968	539.7	549.4	438.0	456.0	696.0	729.6	472.4	1267.6	2052.7	358.7	271.2	520.9	8332.1
	1969	595.0	565.2	679.5	500.3	440.2	696.2	1503.4	2128.9	512.9	1361.2	310.4	466.5	9760.2
	1970	490.0	475.9	510.0	349.6	391.5	465.1	504.8	1326.5	1228.4	655.7	340.0	432.8	7222.3
	1971	436.1	496.1	428.2	484.1	1000.5	491.0	677.8	2175.0	1564.5	255.2	273.6	321.0	8603.1
	1972	431.9	473.8	330.7	305.6	332.2	968.2	753.7	1352.8	1330.1	474.0	353.6	423.4	8095.1
	1973	415.8	432.0	353.2	383.8	370.5	431.7	402.1	287.1	232.4	93.2	67.2	178.2	3647.2
	1974	268.8	376.6	312.0	624.0	357.0	534.3	702.3	823.9	1357.9	347.6	239.2	236.0	6179.4
	1975	356.3	398.2	353.5	303.2	311.2	464.4	652.5	2402.9	3792.3	1969.5	~~994.4~~	653.5	12656.9
	1976	825.3	784.1	895.5	744.8	650.2	804.8	1420.4	3011.1	1937.2	865.0	644.8	545.4	13128.7
	1977	560.7	519.1	449.2	346.6	472.5	435.5	469.3	327.1	273.1	162.7	112.0	211.5	4339.3
Historic	1978	341.0	365.0	411.0	381.0	380.0	721.0	764.0	1354.0	1255.0	929.0	308.0	476.0	7685.0
	1979	532.0	430.0	397.0	373.0	477.0	677.0	791.0	1526.0	731.0	239.0	130.0	226.0	6529.0
	1980	319.0	351.0	332.0	307.0	394.0	443.0	602.0	2015.0	3002.0	1111.0	275.0	481.0	9632.0
	1981	627.0	651.0	622.0	489.0	554.0	508.0	727.0	2914.0	2112.0	533.0	257.0	305.0	10299.0
	1982	518.0	494.0	447.0	340.0	343.0	690.0	875.0	1606.0	2336.0	1196.0	287.0	428.0	10110.0
	AVERAGE	482.2	482.2	437.0	403.3	494.5	575.1	764.5	1547.4	1564.1	621.9	297.3	365.5	8040.0
	MEDIAN	442.4	473.8	411.0	380.0	457.5	545.7	702.3	1427.7	1523.9	511.9	273.6	337.3	7962.8
	80 PERCENTILE	356.3	395.3	339.0	333.6	370.5	443.0	542.7	1046.6	728.7	239.0	169.6	236.0	6479.5
	60 PERCENTILE	431.9	425.5	379.5	351.1	411.7	491.0	632.0	1328.5	1266.6	425.0	257.0	304.0	7459.4
	40 PERCENTILE	504.7	494.0	438.0	430.2	477.0	571.5	764.0	1606.0	1830.1	655.7	284.0	389.0	8330.0
	20 PERCENTILE	595.0	553.7	510.0	489.0	642.0	721.2	981.2	2171.5	2305.7	929.0	353.6	421.0	9760.2
	MAXIMUM	890.4	784.1	895.5	744.8	1000.5	968.2	1503.4	3011.1	3792.3	1969.5	994.4	702.4	13128.7
	MINIMUM	268.8	351.0	312.0	303.2	311.2	403.1	402.1	287.1	232.4	93.2	67.2	178.2	3647.2

Clark Fork River

Historic and reconstituted streamflow (cfs) near Gold Creek, Water Years 1951-1982.

CLARK FORK WATER AVAILABILITY STUDY
CLARK FORK AT DRUMMOND
(FLOW IN CFS)

Reconstituted (1951–1972)

Historic (1973–1982)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOT
1951	735.0	770.0	549.0	549.0	992.0	833.0	1555.0	2431.0	1240.0	1139.0	500.0	655.0	13514.0
1952	937.0	769.0	503.0	575.0	549.0	760.0	1377.0	2500.0	1335.0	421.0	263.0	572.0	10769.0
1953	516.0	524.0	456.0	500.0	540.0	573.0	655.0	1433.0	3794.0	575.0	344.0	440.0	10465.0
1954	475.0	553.0	430.0	449.0	705.0	636.0	975.0	1249.0	1317.0	646.0	355.0	437.0	8234.0
1955	625.0	574.0	473.0	446.0	415.0	537.0	687.0	973.0	1526.0	2166.0	540.0	447.0	9317.0
1956	635.0	531.0	527.0	565.0	531.0	1019.0	1291.0	1960.0	1793.0	663.0	303.0	340.0	9319.0
1957	524.0	626.0	506.0	408.0	663.0	731.0	727.0	1979.0	803.0	265.0	170.0	335.0	7385.0
1958	491.0	545.0	531.0	403.0	451.0	623.0	843.0	2496.0	619.0	533.0	262.0	447.0	8154.0
1959	574.0	712.0	549.0	533.0	554.0	949.0	1100.0	735.0	2357.0	509.0	325.0	510.0	9563.0
1960	1272.0	1050.0	941.0	572.0	693.0	984.0	1132.0	1265.0	1836.0	261.0	209.0	475.0	10747.0
1961	523.0	558.0	452.0	426.0	610.0	565.0	541.0	1203.0	878.0	205.0	123.0	304.0	6393.0
1962	531.0	571.0	437.0	422.0	537.0	644.0	1242.0	2203.0	1658.0	377.0	335.0	436.0	10013.0
1963	914.0	769.0	615.0	462.0	1025.0	752.0	691.0	1512.0	2123.0	587.0	210.0	516.0	10079.0
1964	532.0	549.0	534.0	439.0	454.0	543.0	737.0	1541.0	3499.0	370.0	329.0	635.0	11174.0
1965	721.0	673.0	537.0	553.0	356.0	739.0	1243.0	2367.0	2778.0	844.0	549.0	1033.0	13212.0
1966	334.0	628.0	709.0	512.0	613.0	713.0	795.0	1683.0	335.0	271.0	192.0	297.0	8419.0
1967	523.0	535.0	500.0	469.0	574.0	632.0	800.0	1425.0	2632.0	946.0	372.0	397.0	10035.0
1968	771.0	753.0	584.0	600.0	923.0	950.0	593.0	1457.0	2449.0	454.0	379.0	766.0	10669.0
1969	350.0	785.0	906.0	659.0	537.0	916.0	1903.0	2447.0	618.0	1725.0	338.0	656.0	12458.0
1970	700.0	661.0	630.0	460.0	522.0	512.0	639.0	1527.0	1430.0	530.0	425.0	710.0	9246.0
1971	623.0	639.0	571.0	537.0	1334.0	645.0	853.0	2500.0	1895.0	323.0	342.0	472.0	10880.0
1972	617.0	633.0	441.0	481.0	443.0	1274.0	954.0	1555.0	2205.0	400.0	442.0	630.0	10300.0
1973	594.0	500.0	471.0	505.0	474.0	563.0	509.0	350.0	250.0	118.0	34.0	262.0	4815.0
1974	554.0	523.0	416.0	521.0	476.0	703.0	889.0	947.0	1635.0	440.0	299.0	347.0	7851.0
1975	559.0	553.0	478.0	399.0	415.0	611.0	826.0	2762.0	4569.0	2493.0	1243.0	961.0	15819.0
1976	1179.0	1039.0	1194.0	980.0	867.0	1059.0	1793.0	3461.0	2334.0	1095.0	306.0	302.0	16654.0
1977	521.0	721.0	599.0	456.0	630.0	573.0	594.0	376.0	329.0	206.0	140.0	311.0	5736.0
1978	543.0	516.0	526.0	462.0	506.0	707.0	935.0	1510.0	1504.0	1129.0	401.0	730.0	9780.0
1979	742.0	511.0	529.0	503.0	693.0	913.0	936.0	1757.0	354.0	295.0	223.0	337.0	8512.0
1980	461.0	492.0	447.0	399.0	479.0	567.0	708.0	2346.0	3504.0	1226.0	307.0	555.0	11691.0
1981	822.0	549.0	806.0	642.0	698.0	655.0	864.0	3251.0	2742.0	719.0	275.0	393.0	12736.0
1982	755.0	751.0	672.0	473.0	1138.0	865.0	1220.0	2070.0	2523.0	1561.0	336.0	604.0	13759.0
AVERAGE	683.3	670.5	583.3	537.7	658.6	754.6	968.2	1782.4	1887.5	732.7	370.4	537.6	10222.7
MEDIAN	632.0	658.0	536.0	500.0	610.0	718.0	864.0	1641.0	1335.0	643.0	335.0	436.0	10079.0
80 PERCENTILE	516.0	549.0	452.0	439.0	479.0	573.0	687.0	1203.0	854.0	295.0	212.0	335.0	8234.0
60 PERCENTILE	617.0	591.0	506.0	462.0	549.0	646.0	800.0	1512.0	1526.0	538.0	303.0	447.0	9563.0
40 PERCENTILE	721.0	689.0	534.0	566.0	640.0	752.0	975.0	1979.0	2205.0	830.0	355.0	572.0	10669.0
20 PERCENTILE	822.0	769.0	630.0	642.0	856.0	949.0	1242.0	2496.0	2778.0	1129.0	442.0	710.0	12458.0
MAXIMUM	1272.0	1039.0	1194.0	980.0	1334.0	1274.0	1903.0	3461.0	4569.0	2493.0	1243.0	1033.0	16654.0
MINIMUM	334.0	492.0	416.0	399.0	415.0	537.0	509.0	371.0	250.0	118.0	34.0	262.0	4815.0

Clark Fork River

Historic and reconstituted streamflow (cfs) at Drummond, Water Years 1951-1982.

CLARK FORK WATER AVAILABILITY STUDY
CLARK FORK AT CLINTON-ABOVE ROCK CR.
(FLOW IN CFS)

		OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOT
Reconstituted	1951	837.0	830.3	906.4	591.0	932.7	952.2	1447.1	3118.5	2357.1	1529.5	513.3	807.0	14622.2
	1952	860.0	796.4	700.3	523.7	633.4	343.6	1979.0	2549.6	1127.2	586.5	314.9	476.0	11496.0
	1953	881.0	575.9	503.7	760.9	539.7	655.0	591.9	937.3	3770.2	577.0	354.0	483.0	10619.6
	1954	535.0	662.5	625.9	471.7	707.1	733.2	795.1	914.4	985.5	318.7	406.8	455.0	7663.2
	1955	577.0	573.1	376.3	405.3	435.9	467.4	354.7	1070.1	1371.7	2185.9	453.2	353.0	9179.2
	1956	715.0	725.2	1190.0	553.6	423.1	1484.9	1316.3	2371.9	1477.3	711.4	434.1	531.0	12923.2
	1957	656.0	716.8	685.4	283.0	624.3	747.0	596.5	1513.7	1342.9	372.5	283.0	457.0	8498.2
	1958	740.0	590.5	584.2	523.3	578.3	679.9	929.1	2274.3	2021.3	1105.9	377.6	576.0	11111.6
	1959	695.0	781.8	829.4	761.8	606.1	1002.3	1323.0	1154.7	1539.1	277.4	220.2	567.0	9757.5
	1960	1024.0	1044.7	639.3	455.7	638.8	1260.4	1453.6	1444.5	1249.9	320.6	437.7	577.0	10594.2
	1961	590.0	638.7	823.2	456.6	573.4	544.0	507.3	552.0	757.0	437.3	156.5	492.0	6820.0
	1962	829.0	621.3	457.0	424.5	530.6	550.1	1590.3	1390.5	1295.5	512.4	349.4	525.0	9092.1
	1963	712.0	714.9	935.5	722.2	1072.0	351.0	1015.6	1391.4	1700.5	929.3	327.6	642.0	10329.0
	1964	542.0	535.5	402.2	460.1	515.1	571.3	1362.4	2033.1	3300.6	1061.3	501.4	774.0	12217.7
	1965	735.0	733.2	1132.8	1041.3	1007.4	895.2	2046.9	2038.9	2969.5	1238.4	556.9	1332.0	15535.4
	1966	1104.0	977.3	750.7	695.0	611.5	947.0	1253.0	422.1	772.8	419.5	271.2	335.0	8640.2
	1967	551.0	604.3	528.0	520.0	597.0	433.6	367.7	2347.2	3707.9	994.5	423.1	477.0	12347.3
	1968	970.0	934.1	513.2	553.0	1155.7	1189.6	1062.1	1293.3	2035.3	745.9	530.6	1043.0	12221.3
	1969	950.0	832.7	703.5	340.2	570.9	1115.0	2443.1	1533.6	1413.6	1649.3	416.3	675.0	13528.6
	1970	803.0	779.9	623.8	570.7	594.2	513.6	300.2	2064.5	1905.6	1136.6	403.1	503.0	11029.4
	1971	762.0	739.2	573.9	692.4	1121.1	549.5	645.4	1524.6	1765.1	591.4	233.9	562.0	10054.5
	1972	736.0	771.1	690.2	731.6	738.0	1771.0	1395.9	2169.0	2317.0	1354.6	534.2	633.0	14341.6
	1973	812.0	775.0	684.5	674.6	553.3	528.4	512.4	509.4	614.7	265.0	154.7	345.0	6529.0
	1974	438.0	712.9	553.9	744.9	529.6	705.4	1294.6	1273.5	1763.3	729.6	400.4	475.0	9651.2
	1975	522.0	967.4	567.4	509.1	495.9	583.6	996.0	3081.6	4701.1	2628.5	1293.1	1151.0	17396.7
	1976	1362.0	1172.7	1366.1	1021.7	844.5	1147.2	2195.7	3590.1	2333.4	1268.2	269.0	975.0	13195.3
	1977	972.0	821.0	637.4	450.3	610.6	599.3	555.6	432.0	371.1	273.6	184.7	363.0	5427.7
	1978	647.0	563.4	713.3	530.4	539.7	1174.3	1379.2	1529.1	1327.5	1253.3	547.2	1383.0	11417.1
Historic	1979	909.0	737.2	670.1	592.7	733.9	1071.3	1161.6	1852.2	1030.9	446.4	273.5	453.0	9962.3
	1980	541.0	547.0	500.0	430.0	523.0	624.0	810.0	2609.0	3909.0	1419.0	357.0	744.0	12903.0
	1981	951.0	1036.0	935.0	739.0	314.0	733.0	955.0	3615.0	2910.0	794.0	365.0	442.0	14309.0
	1982	759.0	772.0	725.0	595.0	1322.0	1057.0	1332.0	2284.0	3052.0	1203.0	509.0	639.0	14379.0
	AVERAGE	772.7	757.7	692.1	595.7	712.4	374.3	1202.5	1811.4	1994.2	931.1	426.3	632.8	11404.3
	MEDIAN	740.0	733.2	684.5	570.7	630.6	343.6	1161.6	1613.7	1763.3	794.0	403.1	567.0	11111.6
	10 PERCENTILE	591.0	621.3	553.9	455.7	553.3	623.4	610.0	1070.1	1127.2	419.5	233.0	455.0	9092.1
	30 PERCENTILE	695.0	712.9	626.9	526.0	606.1	733.0	965.0	1444.5	1413.6	591.4	357.0	492.0	10329.0
	70 PERCENTILE	808.0	772.0	689.3	563.0	673.4	895.2	1328.0	2064.6	2021.3	1061.3	423.1	609.0	12217.7
	90 PERCENTILE	951.0	332.7	750.7	744.9	870.9	1147.2	1453.6	2509.0	3052.0	1354.6	534.2	774.0	14309.0
	MAXIMUM	1362.0	1172.7	1366.1	1041.3	1322.0	1771.0	2443.1	3615.0	4701.1	2628.5	1293.1	1332.0	13196.8
	MINIMUM	434.0	547.0	376.3	283.0	423.1	467.4	512.4	422.1	371.1	265.0	154.7	345.0	5427.7

Clark Fork River

Historic and reconstituted streamflow (cfs) near Clinton (above Rock Creek), Water Years 1951-198

CLARK FORK WATER AVAILABILITY STUDY
ROCK CREEK NEAR CLINTON
(FLOW IN CFS)

		OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOT
Reconstituted	1951	343.0	266.0	230.0	205.0	293.0	234.0	737.0	2514.0	2233.0	925.0	330.0	338.0	8303.0
	1952	339.0	319.0	210.0	211.0	205.0	191.0	338.0	2474.0	1507.0	535.0	233.0	273.0	7593.0
	1953	228.0	211.0	171.0	144.0	197.0	173.0	304.0	1015.0	3122.0	997.0	372.0	257.0	7191.0
	1954	200.0	174.0	175.0	158.0	221.0	191.0	499.0	1775.0	1703.0	1127.0	352.0	258.0	7051.0
	1955	261.0	235.0	197.0	172.0	149.0	156.0	272.0	1054.0	2203.0	1248.0	402.0	255.0	6609.0
	1956	216.0	185.0	194.0	175.0	170.0	237.0	332.0	1959.0	1905.0	640.0	354.0	259.0	7236.0
	1957	250.0	223.0	203.0	207.0	199.0	298.0	247.0	2201.0	1947.0	548.0	245.0	225.0	6548.0
	1958	210.0	199.0	174.0	144.0	175.0	197.0	401.0	2273.0	1545.0	547.0	234.0	233.0	6317.0
	1959	244.0	240.0	244.0	180.0	192.0	297.0	608.0	1357.0	2655.0	917.0	384.0	323.0	7551.0
	1960	416.0	295.0	347.0	227.0	213.0	327.0	549.0	1359.0	1576.0	494.0	269.0	250.0	6492.0
	1961	209.0	249.0	177.0	164.0	214.0	212.0	337.0	1454.0	1733.0	739.0	195.0	227.0	5509.0
	1962	247.0	200.0	180.0	148.0	206.0	153.0	933.0	1925.0	1913.0	673.0	343.0	285.0	7231.0
	1963	351.0	271.0	261.0	213.0	277.0	267.0	431.0	1609.0	1971.0	734.0	274.0	246.0	6995.0
	1964	233.0	233.0	167.0	170.0	169.0	158.0	353.0	1726.0	3435.0	1051.0	379.0	340.0	8419.0
	1965	284.0	277.0	214.0	171.0	248.0	256.0	321.0	2227.0	3033.0	1098.0	484.0	387.0	9512.0
	1966	417.0	243.0	246.0	204.0	197.0	231.0	524.0	1759.0	1031.0	493.0	219.0	214.0	5723.0
	1967	199.0	227.0	171.0	153.0	194.0	226.0	283.0	1119.0	3295.0	845.0	336.0	236.0	7255.0
	1968	269.0	251.0	245.0	235.0	273.0	314.0	345.0	1230.0	2251.0	650.0	343.0	334.0	6731.0
	1969	357.0	339.0	233.0	254.0	211.0	211.0	903.0	2359.0	1411.0	1103.0	326.0	273.0	8023.0
	1970	352.0	211.0	169.0	139.0	200.0	233.0	232.0	1447.0	2609.0	375.0	357.0	308.0	7217.0
	1971	264.0	294.0	191.0	195.0	355.0	258.0	539.0	2631.0	2250.0	756.0	315.0	260.0	8359.0
Historic	1972	228.0	183.0	185.0	167.0	173.0	350.0	547.0	2061.0	3543.0	922.0	416.0	314.0	9103.0
	1973	291.0	279.0	195.0	167.0	157.0	194.0	244.0	837.0	846.0	329.0	152.0	215.0	3878.0
	1974	195.0	193.0	181.0	307.0	214.0	221.0	712.0	1709.0	3293.0	325.0	358.0	261.0	8579.0
	1975	233.0	203.0	169.0	155.0	155.0	171.0	236.0	1059.0	3755.0	1908.0	635.0	339.0	9083.0
	1976	474.0	430.0	460.0	329.0	285.0	318.0	896.0	3676.0	2723.0	1125.0	502.0	344.0	11563.0
	1977	295.0	244.0	205.0	177.0	186.0	184.0	301.0	544.0	578.0	283.0	159.0	137.0	3342.0
	1978	221.0	210.0	229.0	173.0	175.0	351.0	767.0	1343.0	2295.0	1032.0	376.0	325.0	8003.0
	1979	246.0	202.0	197.0	171.0	197.0	220.0	334.0	1609.0	1344.0	430.0	258.0	212.0	5420.0
	1980	132.0	161.0	167.0	136.0	153.0	166.0	498.0	2362.0	2229.0	746.0	305.0	309.0	7417.0
	1981	277.0	324.0	220.0	236.0	218.0	215.0	401.0	2077.0	2213.0	343.0	301.0	266.0	7651.0
	1982	175.0	232.0	214.0	193.0	253.0	275.0	493.0	1959.0	2965.0	1202.0	402.0	322.0	[illegible]
	AVERAGE	250.9	242.1	216.0	194.7	210.6	237.2	521.5	1738.7	2231.1	826.3	338.0	280.4	7367.4
	MEDIAN	254.0	235.0	197.0	173.0	200.0	231.0	476.0	1776.0	2229.0	843.0	343.0	269.0	7263.0
	20 PERCENTILE	219.0	200.0	176.0	164.0	173.0	184.0	301.0	1230.0	1545.0	548.0	269.0	233.0	6492.0
	40 PERCENTILE	244.0	211.0	189.0	171.0	197.0	212.0	401.0	1609.0	1947.0	734.0	315.0	260.0	7191.0
	60 PERCENTILE	273.0	243.0	214.0	189.0	211.0	255.0	539.0	1959.0	2295.0	917.0	354.0	285.0	7651.0
	80 PERCENTILE	342.0	294.0	245.0	235.0	248.0	314.0	721.0	2227.0	3122.0	1103.0	402.0	325.0	8579.0
	MAXIMUM	474.0	430.0	460.0	329.0	355.0	351.0	933.0	3676.0	3755.0	1908.0	635.0	389.0	11563.0
	MINIMUM	132.0	161.0	167.0	136.0	149.0	153.0	232.0	544.0	578.0	283.0	152.0	137.0	3342.0

Rock Creek

Historic and reconstituted streamflow (cfs), Water Years 1951-1982.

All
Reconstituted

CLARK FORK WATER AVAILABILITY STUDY
CLARK FORK-ABOVE CONFLUENCE WITH BLACKFOOT R.
(FLOW IN CFS)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOT
1951	1200.0	1122.0	1070.0	764.0	1313.0	1269.0	2343.0	6079.0	4796.0	2310.0	1054.0	1135.0	24565.0
1952	1259.0	1140.0	950.0	905.0	931.0	1103.0	2956.0	5438.0	2719.0	1246.0	529.0	754.0	19925.0
1953	839.0	815.0	779.0	993.0	845.0	885.0	1048.0	2112.0	7175.0	1598.0	761.0	740.0	18557.0
1954	735.0	557.0	329.0	533.0	993.0	985.0	1355.0	2792.0	2953.0	1459.0	805.0	723.0	15242.0
1955	839.0	831.0	839.0	622.0	523.0	564.0	1191.0	2243.0	3563.0	3525.0	911.0	543.0	16379.0
1956	951.0	912.0	1443.0	797.0	535.0	1251.0	2845.0	5130.0	3494.0	1331.0	941.0	830.0	21110.0
1957	915.0	957.0	917.0	525.0	885.0	1110.0	1261.0	3994.0	3391.0	936.0	556.0	682.0	16140.0
1958	959.0	911.0	793.0	732.0	833.0	936.0	1400.0	4605.0	3720.0	1799.0	599.0	809.0	18216.0
1959	929.0	1045.0	1118.0	1036.0	858.0	1387.0	2036.0	2650.0	4310.0	1206.0	625.0	890.0	18082.0
1960	1440.0	1372.0	1055.0	909.0	915.0	1697.0	2212.0	2964.0	2920.0	928.0	750.0	827.0	17799.0
1961	759.0	959.0	722.0	577.0	954.0	804.0	990.0	2435.0	2547.0	724.0	373.0	719.0	12779.0
1962	915.0	841.0	550.0	625.0	699.0	1077.0	2422.0	3470.0	3306.0	1213.0	732.0	810.0	15963.0
1963	1073.0	1003.0	923.0	575.0	1455.0	1192.0	1523.0	3155.0	3305.0	1702.0	634.0	958.0	17934.0
1964	875.0	850.0	586.0	437.0	735.0	779.0	1313.0	3985.0	6974.0	2157.0	930.0	1114.0	21500.0
1965	1054.0	1030.0	1394.0	1341.0	1355.0	1229.0	3022.0	4543.0	6226.0	2338.0	1074.0	1769.0	26433.0
1966	1521.0	1251.0	1028.0	971.0	869.0	1261.0	1909.0	2228.0	1362.0	930.0	517.0	592.0	14966.0
1967	790.0	330.0	721.0	744.0	350.0	969.0	1216.0	3727.0	7293.0	1982.0	303.0	713.0	20528.0
1968	1259.0	1214.0	800.0	830.0	1543.0	1607.0	1437.0	2667.0	4440.0	1427.0	951.0	1397.0	19992.0
1969	1347.0	1243.0	971.0	1125.0	1168.0	1423.0	3535.0	4062.0	2931.0	2321.0	784.0	953.0	22446.0
1970	1170.0	1015.0	844.0	837.0	853.0	905.0	1157.0	3741.0	4658.0	2111.0	800.0	916.0	19227.0
1971	1160.0	1055.0	794.0	773.0	1537.0	964.0	1233.0	4375.0	4143.0	1372.0	527.0	322.0	19116.0
1972	954.0	977.0	904.0	939.0	934.0	2275.0	2048.0	4491.0	6372.0	2333.0	1003.0	947.0	24437.0
1973	1103.0	1028.0	909.0	925.0	775.0	877.0	795.0	1403.0	1507.0	605.0	332.0	561.0	10820.0
1974	533.0	929.0	753.0	1144.0	796.0	1153.0	2104.0	3124.0	5139.0	1585.0	809.0	736.0	18958.0
1975	355.0	395.0	760.0	737.0	700.0	914.0	1307.0	4433.0	8310.0	4646.0	2056.0	1540.0	27734.0
1976	1330.0	1639.0	1383.0	1477.0	1213.0	1565.0	3253.0	7665.0	5291.0	2447.0	1457.0	1319.0	31050.0
1977	1267.0	1031.0	921.0	653.0	357.0	836.0	1007.0	1024.0	977.0	568.0	351.0	555.0	10147.0
1978	833.0	795.0	971.0	783.0	324.0	1623.0	2250.0	3542.0	3737.0	2338.0	978.0	1414.0	20179.0
1979	1155.0	952.0	375.0	337.0	1009.0	1335.0	1593.0	3557.0	2474.0	395.0	374.0	655.0	15091.0
1980	720.0	754.0	717.0	510.0	783.0	837.0	1134.0	5202.0	5335.0	2275.0	730.0	979.0	21103.0
1981	1131.0	1317.0	1202.0	999.0	1083.0	995.0	1420.0	5330.0	5335.0	1555.0	577.0	694.0	22433.0
1982	1177.0	1057.0	966.0	432.0	1714.0	1443.0	1951.0	4696.0	5333.0	3134.0	949.0	1033.0	23254.0
AVERAGE	1054.2	1022.4	936.2	864.1	994.4	1187.9	1807.2	3796.5	4377.4	1798.9	806.3	911.1	19557.2
MEDIAN	1054.0	1003.0	909.0	837.0	899.0	1110.0	1583.0	3741.0	4148.0	1655.0	734.0	822.0	19116.0
80 PERCENTILE	533.0	850.0	753.0	683.0	776.0	885.0	1191.0	2650.0	2920.0	936.0	626.0	694.0	15140.0
60 PERCENTILE	929.0	959.0	844.0	783.0	857.0	993.0	1400.0	3470.0	3633.0	1427.0	730.0	754.0	15216.0
40 PERCENTILE	1127.0	1038.0	923.0	932.0	954.0	1229.0	1751.0	4062.0	4658.0	1882.0	805.0	890.0	20179.0
20 PERCENTILE	1259.0	1214.0	1065.0	999.0	1213.0	1565.0	2428.0	4606.0	6358.0	2338.0	978.0	1114.0	22446.0
MAXIMUM	1536.0	1639.0	1383.0	1477.0	1714.0	2275.0	3535.0	7665.0	8310.0	4646.0	2056.0	1769.0	31050.0
MINIMUM	[illegible]	[illegible]	586.0	525.0	628.0	564.0	735.0	1024.0	977.0	568.0	332.0	555.0	10147.0

Clark Fork River

Reconstituted streamflow (cfs), near Turah (above Blackfoot River), Water Years 1951-1982.

All
Historic

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                                        CLARK FORK WATER AVAILABILITY STUDY
                                        BLACKFOOT RIVER AT BONNER
              OCT      NOV      DEC      JAN      FEB      MAR      APR      MAY      JUN      JUL      AUG      SEP      TOT
                                                  (FLOW IN CFS)

    1951     755.0    919.0    655.0    747.0    921.0    304.0   2907.0   7931.0   5634.0   2759.0   1151.0    943.0  26453.0
    1952     959.0    739.0    519.0    542.0    560.0    536.0   3227.0   6772.0   3130.0   1215.0    749.0    558.0  19454.0
    1953     510.0    516.0    473.0    559.0    591.0    535.0    899.0   3530.0   9114.0   2626.0    956.0    797.0  21131.0
    1954     617.0    590.0    557.0    502.0    527.0    593.0   1514.0   6178.0   5576.0   3209.0   1006.0    792.0  21955.0
    1955     712.0    647.0    595.0    535.0    491.0    469.0    797.0   3307.0   5306.0   2349.0   1131.0    634.0  17532.0
    1956     521.0    607.0    417.0    541.0    539.0    540.0   2140.0   6870.0   5533.0   1796.0    924.0    644.0  22592.0
    1957     619.0    589.0    645.0    521.0    516.0    592.0   1241.0   7165.0   4235.0   1222.0    577.0    603.0  18797.0
    1958     574.0    557.0    547.0    411.0    433.0    591.0   1460.0   5995.0   4730.0   1447.0    739.0    575.0  18200.0
    1959     642.0    825.0    771.0    709.0    695.0    891.0   3116.0   5572.0   8720.0   2456.0   1079.0    955.0  26857.0
    1960    1547.0   1460.0   1233.0    764.0    664.0   1115.0   3067.0   3555.0   4162.0   1312.0    749.0    614.0  20364.0
    1961     546.0    540.0    469.0    481.0    597.0    613.0   1142.0   4557.0   4932.0   1131.0    599.0    553.0  16160.0
    1962     537.0    541.0    471.0    390.0    525.0    517.0   2957.0   5818.0   5745.0   1331.0    376.0    712.0  21330.0
    1963     535.0    578.0    547.0    545.0   1054.0    836.0   1630.0   3575.0   3655.0   1554.0    729.0    642.0  16340.0
    1964     544.0    549.0    511.0    503.0    473.0    461.0   1046.0   5099.0   3316.0   2179.0    908.0    752.0  21400.0
    1965     570.0    625.0    661.0    592.0    650.0    662.0   3147.0   6842.0   7734.0   2654.0   1131.0   1135.0  25613.0
    1966    1054.0    635.0    585.0    624.0    594.0    735.0   2144.0   4005.0   3283.0   1244.0    670.0    542.0  16327.0
    1967     544.0    555.0    521.0    505.0    515.0    527.0   1096.0   5048.0   9057.0   2544.0    902.0    469.0  22474.0
    1968     471.0    706.0    542.0    531.0    463.0   1158.0   1155.0   2960.0   4304.0   1363.0    772.0    784.0  15934.0
    1969     637.0    724.0    559.0    590.0    551.0    703.0   3903.0   5797.0   3359.0   2670.0    901.0    537.0  21956.0
    1970     653.0    609.0    561.0    499.0    548.0    557.0    953.0   5646.0   6222.0   1890.0    358.0    654.0  19559.0
    1971     557.0    633.0    555.0    570.0   1668.0    910.0   2425.0   8375.0   6442.0   2210.0    944.0    729.0  26221.0
    1972     621.0    512.0    573.0    590.0    511.0   1633.0   2539.0   7259.0   9443.0   2513.0   1125.0    837.0  23547.0
    1973     501.0    476.0    561.0    460.0    473.0    659.0    775.0   2413.0   2145.0    746.0    473.0    446.0  10608.0
    1974     451.0    487.0    435.0    795.0    572.0    776.0   3173.0   5153.0   7941.0   2275.0    954.0    693.0  23621.0
    1975     511.0    567.0    505.0    438.0    473.0    506.0    896.0   4849.0  10460.0   4113.0   1392.0    932.0  25642.0
    1976    1347.0   1092.0   1440.0   1069.0    369.0   1051.0   3930.0   9575.0   5499.0   2255.0   1036.0    784.0  29704.0
    1977     510.0    632.0    525.0    572.0    535.0    437.0    949.0   1583.0   1172.0    533.0    413.0    410.0   8401.0
    1978     446.0    633.0    583.0    434.0    425.0   1067.0   2795.0   4977.0   5313.0   2743.0    939.0    512.0  20925.0
    1979     549.0    590.0    550.0    413.0    564.0    771.0   1412.0   5898.0   4243.0   1228.0    634.0    518.0  17615.0
    1980     552.0    494.0    517.0    410.0    459.0    502.0   1829.0   5528.0   5032.0   1500.0    311.0    737.0  18711.0
    1981     570.0    544.0    751.0    411.0    512.0    864.0   1563.0   5590.0   4512.0   1712.0    759.0    623.0  19447.0
    1982   [illegible] 605.0  573.0    505.0    721.0    936.0   1279.0   5894.0   7227.0   3257.0   1059.0    760.0  24046.0

         AVERAGE     695.3    663.1    636.8    580.0    644.2    757.3   2015.3   5425.5   5723.0   2051.7    873.3    709.3  20725.0
          MEDIAN     553.0    609.0    561.0    535.0    554.0    705.0   1329.0   5590.0   5499.0   2174.0    902.0    654.0  21080.0
  80 PERCENTILE     547.0    541.0    517.0    481.0    491.0    527.0   1045.0   3675.0   4162.0   1244.0    729.0    616.0  17530.0
  60 PERCENTILE     621.0    592.0    555.0    503.0    535.0    613.0   1459.0   5099.0   4433.0   1795.0    811.0    644.0  19559.0
  40 PERCENTILE     671.0    633.0    577.0    559.0    597.0    775.0   2413.0   5613.0   5573.0   2275.0    939.0    729.0  21955.0
  20 PERCENTILE     701.0    724.0    661.0    692.0    721.0    936.0   3113.0   6842.0   8316.0   2654.0   1079.0    792.0  25542.0
         MAXIMUM    1547.0   1460.0   1440.0   1069.0   1668.0   1633.0   3930.0   9575.0  10460.0   4113.0   1392.0   1135.0  29704.0
         MINIMUM     446.0    476.0    469.0    390.0    425.0    461.0    775.0   1583.0   1172.0    533.0    413.0    410.0   8401.0
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Big Blackfoot River

Historic streamflow (cfs) at Bonner, Water Years 1951-1982.

All
Historic

CLARK FORK WATER AVAILABILITY STUDY
CLARK FORK ABOVE MISSOULA
(FLOW IN CFS)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOT
1951	1956.0	2111.0	1329.0	1315.0	2239.0	2073.0	5250.0	14060.0	10430.0	5069.0	2205.0	2071.0	51015.0
1952	2213.0	1927.0	1579.0	1347.0	1461.0	1644.0	6193.0	12210.0	5349.0	2461.0	1377.0	1312.0	39570.0
1953	1319.0	1331.0	1257.0	1363.0	1436.0	1470.0	1947.0	5092.0	16290.0	4224.0	1717.0	1447.0	39608.0
1954	1392.0	1447.0	1326.0	1190.0	1525.0	1521.0	2371.0	3970.0	3841.0	4663.0	1311.0	1515.0	37197.0
1955	1550.0	1473.0	1184.0	1167.0	1119.0	1133.0	1959.0	5550.0	8939.0	6374.0	2012.0	1342.0	33838.0
1956	1332.0	1519.0	2260.0	1459.0	1174.0	2691.0	5535.0	12030.0	9127.0	3177.0	1765.0	1444.0	43702.0
1957	1535.0	1575.0	1562.0	1440.0	1401.0	1802.0	2502.0	11160.0	7677.0	2155.0	1233.0	1255.0	34957.0
1958	1565.0	1451.0	1340.0	1165.0	1316.0	1527.0	2850.0	10500.0	8450.0	3246.0	1439.0	1445.0	35616.0
1959	1621.0	1374.0	1879.0	1765.0	1534.0	2273.0	5154.0	3222.0	13090.0	3842.0	1735.0	1355.0	44939.0
1960	2397.0	2352.0	2232.0	1373.0	1579.0	2512.0	3277.0	6819.0	7032.0	2140.0	1499.0	1443.0	33163.0
1961	1342.0	1429.0	1131.0	1155.0	1551.0	1417.0	2132.0	6992.0	7379.0	1925.0	977.0	1272.0	28835.0
1962	1473.0	1332.0	1127.0	1015.0	1424.0	1594.0	5395.0	9230.0	9051.0	3394.0	1623.0	1522.0	37993.0
1963	1771.0	1635.0	1546.0	1120.0	2509.0	2028.0	3153.0	6530.0	7462.0	3255.0	1363.0	1535.0	34274.0
1964	1473.0	1399.0	1037.0	1192.0	1213.0	1240.0	2954.0	9054.0	15300.0	4336.0	1333.0	1365.0	42920.0
1965	1724.0	1563.0	2355.0	2038.0	2015.0	1391.0	6159.0	11390.0	13960.0	5072.0	2205.0	2374.0	53051.0
1966	2525.0	2037.0	1713.0	1515.0	1463.0	1397.0	4033.0	6233.0	5145.0	2174.0	1147.0	1141.0	31295.0
1967	1334.0	1355.0	1242.0	1250.0	1365.0	1490.0	2312.0	3775.0	16350.0	4426.0	1705.0	1382.0	42322.0
1968	1930.0	1922.0	1522.0	1311.0	2406.0	2765.0	2642.0	5627.0	8744.0	2615.0	1753.0	2131.0	35325.0
1969	2134.0	1973.0	1530.0	1335.0	1319.0	2131.0	7438.0	9859.0	6790.0	5491.0	1685.0	1645.0	44432.0
1970	1333.0	1424.0	1405.0	1226.0	1401.0	1462.0	2020.0	9567.0	10650.0	4010.0	1553.0	1530.0	35555.0
1971	1323.0	1659.0	1342.0	1643.0	3255.0	1674.0	3661.0	12750.0	15530.0	3582.0	1571.0	1551.0	45337.0
1972	1535.0	1339.0	1507.0	1579.0	1495.0	4108.0	4637.0	11750.0	16020.0	4851.0	2129.0	1734.0	53734.0
1973	1904.0	1704.0	1470.0	1285.0	1248.0	1515.0	1570.0	3316.0	3652.0	1351.0	805.0	1007.0	21423.0
1974	1084.0	1415.0	1244.0	1934.0	1428.0	1929.0	5282.0	8277.0	13130.0	3360.0	1762.0	1429.0	42779.0
1975	1466.0	1463.0	1265.0	1225.0	1173.0	1420.0	2203.0	9332.0	19270.0	8759.0	3448.0	2522.0	53546.0
1976	2987.0	2737.0	3323.0	2546.0	2082.0	2616.0	7138.0	17240.0	10790.0	4703.0	2543.0	2103.0	60754.0
1977	1457.0	1693.0	1445.0	1195.0	1392.0	1323.0	1756.0	2507.0	2149.0	1101.0	774.0	965.0	18548.0
1978	1314.0	1234.0	1504.0	1217.0	1249.0	2695.0	5048.0	8519.0	9100.0	5031.0	1917.0	2226.0	41104.0
1979	1554.0	1542.0	1435.0	1255.0	1573.0	2156.0	2995.0	9555.0	5717.0	2123.0	1258.0	1283.0	33735.0
1980	1272.0	1215.0	1274.0	1020.0	1242.0	1339.0	2953.0	10730.0	11470.0	4075.0	1541.0	1715.0	39819.0
1981	1357.0	1251.0	1933.0	1410.0	1995.0	1259.0	3033.0	11420.0	9847.0	3767.0	1479.0	1317.0	41825.0
1982	[illegible]	1472.0	[illegible]	1434.0	2435.0	2372.0	3250.0	10300.0	13550.0	6391.0	2007.0	1792.0	48300.0
AVERAGE	1749.5	1633.5	1573.0	1444.2	1638.7	1945.2	3422.6	9222.0	10130.3	3950.7	1635.1	1620.4	40342.2
MEDIAN	1724.0	1624.0	1504.0	1333.0	1463.0	1574.0	3153.0	9332.0	9127.0	3262.0	1705.0	1522.0	38819.0
80 PERCENTILE	1392.0	1415.0	1244.0	1163.0	1249.0	1462.0	2203.0	6519.0	7032.0	2174.0	1363.0	1312.0	34274.0
60 PERCENTILE	1556.0	1519.0	1405.0	1250.0	1424.0	1594.0	2871.0	6775.0	8841.0	3255.0	1571.0	1444.0	35163.0
40 PERCENTILE	1804.0	1636.0	1532.0	1311.0	1551.0	1997.0	4053.0	9659.0	10790.0	4224.0	1753.0	1580.0	42779.0
20 PERCENTILE	1957.0	1923.0	1879.0	1745.0	2015.0	2616.0	5395.0	11420.0	13960.0	5072.0	2007.0	1865.0	45337.0
MAXIMUM	2987.0	2737.0	3323.0	2546.0	3255.0	4108.0	7438.0	17240.0	19270.0	8759.0	3448.0	2374.0	60754.0
MINIMUM	1084.0	1215.0	1037.0	1015.0	1119.0	1133.0	1570.0	2507.0	2149.0	1101.0	774.0	965.0	18548.0

Clark Fork River

Historic streamflow (cfs) above Missoula (below Blackfoot River), Water Years 1951-1982.

CLARK FORK WATER AVAILABILITY STUDY
EXCESS FLOW-CLARK FK NR DEER LODGE
(FLOW IN CFS)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOT
1951	269.0	264.2	221.5	184.5	366.3	295.5	592.6	789.3	331.6	361.8	115.0	185.5	3977.0
1952	334.4	263.7	201.8	197.5	162.5	259.6	474.6	660.0	381.9	70.0	17.8	150.2	3174.2
1953	131.9	151.0	128.9	160.0	204.4	173.6	182.6	341.4	1200.0	128.5	51.0	94.8	2948.1
1954	114.2	166.7	116.4	134.5	234.3	202.6	309.7	284.7	357.8	156.2	55.6	93.5	2226.2
1955	180.0	174.0	139.4	133.0	100.9	157.0	191.7	171.9	428.8	733.1	131.4	97.7	2639.1
1956	183.0	181.9	163.0	193.0	154.3	378.7	439.3	228.0	519.6	161.9	34.2	52.8	2689.8
1957	178.3	198.0	152.9	113.0	215.0	246.3	208.1	503.7	183.0	10.7	0.0	71.7	2080.6
1958	121.1	160.7	112.1	114.0	117.5	196.6	255.6	658.8	120.5	114.4	25.6	97.7	2094.6
1959	156.8	237.5	173.5	229.0	164.8	346.5	393.8	121.8	711.4	103.4	43.3	124.2	2806.1
1960	457.0	393.0	337.7	249.0	228.8	362.6	374.1	289.8	534.2	9.2	0.0	109.5	3344.9
1961	134.9	166.7	127.0	123.0	190.6	169.9	131.8	270.9	208.5	0.0	0.0	37.7	1560.9
1962	159.8	172.7	119.8	121.0	157.0	206.2	419.2	570.9	477.1	243.3	47.4	118.3	2812.7
1963	260.0	263.3	205.7	141.0	381.5	255.9	193.3	363.6	631.8	133.1	0.0	126.7	2955.9
1964	181.8	162.5	167.3	129.5	123.4	159.8	232.7	402.3	1099.7	240.6	126.9	197.7	3224.1
1965	220.0	221.9	196.6	241.5	303.8	249.9	419.6	620.1	854.5	230.7	194.1	343.9	4096.6
1966	281.5	290.9	250.3	216.0	192.0	240.3	236.4	414.9	194.2	13.0	0.0	34.7	2364.2
1967	126.3	156.1	150.0	144.5	174.0	223.7	238.0	397.5	804.9	269.5	62.5	76.7	2823.8
1968	241.5	261.0	190.3	210.0	336.9	351.6	155.2	347.1	742.7	82.5	49.0	231.7	3199.5
1969	275.5	271.1	344.9	239.5	180.0	331.4	690.2	644.1	120.1	564.7	69.1	198.1	3928.7
1970	211.0	214.1	236.4	140.0	150.1	191.5	172.0	368.1	413.2	225.4	84.3	208.2	2614.2
1971	177.9	226.9	184.1	228.5	523.6	207.2	261.8	660.0	550.9	32.7	50.2	108.2	3212.1
1972	175.3	212.7	121.7	150.5	113.8	496.0	301.1	376.5	659.7	138.0	91.2	174.6	3011.1
1973	165.4	136.0	136.1	162.5	137.2	171.3	118.7	9.0	5.2	0.0	0.0	20.0	1111.4
1974	75.1	150.6	109.7	320.5	129.0	233.4	274.5	194.1	466.2	77.2	32.6	55.7	2118.6
1975	128.9	164.4	139.4	109.5	100.9	191.1	248.7	738.6	1463.5	857.3	419.6	313.6	4875.5
1976	417.0	410.9	483.1	400.0	308.8	397.1	647.2	948.3	703.6	326.1	240.5	246.8	5529.4
1977	254.4	241.7	197.5	138.0	199.8	173.6	153.5	22.8	21.9	0.0	0.0	40.6	1443.8
1978	143.5	147.4	162.5	141.0	142.8	327.2	318.4	363.0	421.4	339.0	74.4	237.6	2818.1
1979	218.0	195.0	171.0	138.0	218.0	297.0	263.0	356.0	186.0	21.0	5.5	38.0	2106.5
1980	114.0	146.0	144.0	118.0	172.0	219.0	262.0	629.0	1061.0	378.0	45.0	205.0	3493.0
1981	280.0	294.0	263.0	221.0	208.0	209.0	272.0	881.0	809.0	173.0	30.0	91.0	3731.0
1982	208.0	242.0	218.0	176.0	391.0	276.0	332.0	611.0	1016.0	503.0	40.0	163.0	4176.0
AVERAGE	205.5	218.4	189.5	178.7	212.0	256.2	305.1	444.9	552.5	209.3	66.8	135.8	2974.6
MEDIAN	181.8	212.7	171.0	160.0	190.6	240.3	263.0	397.5	534.2	156.2	47.4	118.3	2948.1
80 PERCENTILE	131.9	162.5	128.9	129.5	137.2	191.1	191.7	270.9	194.2	21.0	0.0	55.7	2118.6
60 PERCENTILE	175.3	131.9	152.9	141.0	164.8	209.0	248.7	363.0	428.8	114.4	34.2	97.7	2806.1
40 PERCENTILE	211.0	226.9	190.3	193.0	204.4	255.9	301.1	503.7	659.7	225.4	51.0	150.2	3174.2
20 PERCENTILE	275.5	263.7	236.4	229.0	303.8	346.5	419.2	658.8	854.5	339.0	91.2	208.2	3731.0
MAXIMUM	457.0	410.9	483.1	400.0	523.6	496.0	690.2	948.3	1463.5	857.3	419.6	343.9	5529.4
MINIMUM	75.1	146.0	109.7	109.5	100.9	157.0	118.7	9.0	5.2	0.0	0.0	20.0	1111.4

Clark Fork River

Water available in excess of the low habitat potential instream flow request (90 cfs) at Deerlodge, Water Years 1951-1982.

CLARK FORK WATER AVAILABILITY STUDY
EXCESS FLOW-CLARK FK NR GARRISON
(FLOW IN CFS)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOT
1951	239.0	228.2	186.5	135.5	421.3	288.5	710.6	1080.3	750.6	364.8	72.0	167.5	4645.0
1952	329.4	226.7	172.8	144.5	121.5	259.6	699.6	1349.0	512.9	74.0	0.0	94.2	3984.3
1953	70.9	81.0	61.9	112.0	148.4	137.6	201.6	977.4	2455.0	226.5	4.0	33.8	4510.1
1954	44.3	98.7	49.4	72.5	206.3	166.6	359.7	742.7	650.8	150.2	0.0	33.5	2574.7
1955	122.0	117.0	72.4	62.0	23.9	95.0	191.7	435.9	836.8	788.1	106.4	55.7	2907.1
1956	140.0	127.9	109.0	139.0	91.3	456.7	633.3	1262.0	798.6	159.9	0.0	15.8	3933.5
1957	123.3	154.0	109.9	48.0	161.0	235.3	259.1	1497.7	441.0	0.0	0.0	5.7	3034.9
1958	65.1	104.7	40.1	47.0	62.5	150.6	264.6	1143.8	412.5	76.4	0.0	57.7	2425.0
1959	105.8	183.5	148.5	183.0	123.8	329.5	486.8	685.8	1427.4	127.4	0.0	98.2	3904.8
1960	432.0	329.0	301.7	197.0	178.8	435.6	579.1	999.8	715.2	0.0	0.0	47.5	4214.7
1961	93.9	120.7	68.0	59.0	160.6	125.9	122.8	505.9	394.5	0.0	0.0	0.0	1651.3
1962	88.8	104.7	50.8	43.0	91.0	162.2	552.2	1357.9	740.1	299.3	0.0	53.3	3548.3
1963	236.0	235.3	171.7	72.0	500.5	251.9	256.3	482.6	914.8	135.1	0.0	85.7	3341.9
1964	143.8	119.5	101.3	69.5	88.4	94.8	277.7	653.3	1981.7	366.6	93.9	165.7	4156.1
1965	167.0	167.9	148.6	219.5	302.8	291.9	586.6	1262.1	1477.5	293.7	188.1	348.9	5454.6
1966	278.5	259.9	275.3	175.0	195.0	285.3	456.4	1296.9	321.2	0.0	0.0	0.0	3553.5
1967	53.3	91.1	86.0	82.5	120.0	188.7	231.0	915.5	1695.9	304.5	0.0	36.7	3805.2
1968	251.5	234.0	137.3	151.0	413.9	431.6	224.2	1207.1	1023.7	83.5	24.0	225.7	4407.5
1969	275.5	266.1	311.9	190.5	146.0	408.4	1048.2	1677.1	372.1	541.7	5.1	156.1	5398.7
1970	160.0	154.1	180.4	30.0	107.1	157.5	284.0	867.1	815.2	324.4	29.3	174.2	3333.2
1971	139.9	198.9	118.1	191.5	589.6	247.2	359.8	1145.0	930.9	21.7	0.0	62.2	3994.9
1972	126.3	158.7	62.7	116.5	80.8	642.0	454.1	979.5	1411.7	141.0	47.2	140.6	4361.1
1973	115.4	136.0	70.1	98.5	84.2	121.3	97.7	32.0	0.0	0.0	0.0	0.0	755.2
1974	0.1	89.6	42.7	328.5	78.0	243.4	387.5	526.1	831.2	37.2	0.0	0.0	2564.2
1975	69.9	108.4	77.4	44.5	33.9	136.1	245.7	1581.6	3156.5	1157.3	500.6	311.6	7423.5
1976	436.0	422.9	572.1	425.0	300.8	450.1	1023.2	2014.3	1111.6	404.1	242.5	222.6	7625.4
1977	230.4	211.7	151.5	76.0	158.8	131.6	159.5	6.8	0.0	0.0	0.0	0.0	1126.3
1978	75.5	82.4	107.5	81.0	80.8	426.2	522.4	922.0	713.4	424.0	32.4	222.6	3690.1
1979	183.0	147.0	110.0	78.0	186.0	321.0	400.0	995.0	355.0	0.0	0.0	0.0	2775.0
1980	53.0	91.0	77.0	53.0	117.0	167.0	339.0	1265.0	1738.0	495.0	14.0	179.0	4588.0
1981	265.0	304.0	303.0	195.0	252.0	229.0	440.0	2231.0	1351.0	246.0	0.0	46.0	5862.0
1982	190.0	218.0	183.0	124.0	514.0	311.0	491.0	1132.0	1616.0	631.0	4.0	124.0	5538.0
AVERAGE	165.8	174.3	145.6	128.1	191.9	261.8	417.0	1038.4	998.5	246.0	42.6	98.9	3909.0
MEDIAN	140.0	154.1	110.0	112.0	148.4	247.2	387.5	1132.0	836.8	159.9	0.0	62.2	3933.5
80 PERCENTILE	70.9	104.7	68.0	62.0	84.2	137.6	231.0	653.3	412.5	0.0	0.0	5.7	2775.0
60 PERCENTILE	122.0	127.9	101.3	80.0	120.0	188.7	284.0	977.4	740.1	127.4	0.0	47.5	3553.5
40 PERCENTILE	167.0	188.5	148.5	139.0	161.0	285.3	454.1	1207.1	1023.7	293.7	4.0	98.2	4156.1
20 PERCENTILE	265.0	235.3	183.0	191.5	300.8	426.2	579.1	1357.9	1616.0	424.0	47.2	179.0	5398.7
MAXIMUM	436.0	422.9	572.1	425.0	589.6	642.0	1048.2	2231.0	3156.5	1157.3	500.6	348.9	7625.4
MINIMUM	0.1	81.0	40.1	44.5	23.9	94.8	97.7	6.8	0.0	0.0	0.0	0.0	755.2

Clark Fork River

Water available in excess of the low habitat potential instream flow request (200 cfs) at Garrison, Water Years 1951-1982.

CLARK FORK WATER AVAILABILITY STUDY
EXCESS FLOW-CLARK FK NR GOLD CR
(FLOW IN CFS)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOT
1951	384.5	354.4	286.7	217.2	544.0	436.9	1115.3	2350.0	829.2	739.3	200.0	246.1	7703.7
1952	490.9	353.7	256.0	237.0	211.7	377.6	887.8	1975.0	952.0	132.6	10.4	189.0	6073.7
1953	161.2	177.3	142.0	180.0	280.0	235.5	325.3	1051.1	2949.0	254.2	75.2	99.2	5930.0
1954	132.5	201.8	122.5	141.2	328.7	283.4	570.2	886.6	893.1	311.9	84.0	97.2	4053.2
1955	239.6	213.3	158.5	139.0	111.3	208.1	342.7	559.5	1066.6	1511.1	232.0	104.0	4885.6
1956	244.5	225.5	195.2	230.2	198.2	574.4	819.9	722.2	1288.2	323.8	42.4	31.2	4895.8
1957	236.8	250.7	179.5	108.6	297.2	355.6	374.3	1521.7	466.5	9.3	0.0	61.8	3862.1
1958	143.7	192.4	115.7	110.1	138.2	273.5	466.0	1971.5	313.8	225.0	25.6	104.0	4079.5
1959	201.8	312.6	211.7	284.9	215.5	521.2	732.2	414.2	1756.3	202.1	60.0	146.8	5059.4
1960	690.4	556.0	468.2	315.3	319.7	547.8	694.3	901.4	1323.9	6.2	0.0	123.0	5946.3
1961	166.1	201.8	139.0	123.8	257.5	229.4	227.4	846.6	528.7	0.0	0.0	6.7	2727.0
1962	206.7	211.1	127.7	120.7	202.7	289.4	781.2	1716.6	1184.4	492.8	68.0	137.3	5538.8
1963	369.8	353.0	262.0	151.1	568.7	371.5	345.9	1115.4	1562.1	263.7	0.0	150.9	5514.2
1964	242.4	195.3	202.0	133.6	148.0	212.7	421.7	1227.7	2704.2	487.3	223.2	265.8	6463.9
1965	304.7	288.2	247.7	303.9	442.0	361.6	782.0	1859.3	2105.7	466.8	354.4	502.4	8018.7
1966	404.8	396.2	331.7	265.1	259.7	345.7	428.8	1264.2	493.9	14.1	0.0	2.0	4206.2
1967	152.1	135.2	175.0	156.4	230.5	318.3	432.0	1213.7	1984.6	547.3	97.6	70.0	5562.8
1968	339.7	349.4	238.0	256.0	496.0	529.6	272.4	1067.6	1832.7	158.7	71.2	320.9	5932.1
1969	395.0	365.2	479.5	300.8	240.2	496.2	1303.4	1928.9	312.9	1161.2	110.4	266.5	7360.2
1970	290.0	275.9	310.0	149.6	191.5	265.1	304.8	1128.5	1028.4	455.7	140.0	282.8	4822.3
1971	236.1	296.1	228.2	284.1	800.5	291.0	477.8	1975.0	1364.5	55.2	73.6	121.0	6203.1
1972	231.9	273.8	130.7	165.6	132.2	768.2	553.7	1152.8	1630.1	274.0	153.6	228.4	5695.1
1973	215.8	232.0	153.2	183.8	170.5	231.7	202.1	87.1	32.4	0.0	0.0	0.0	1508.6
1974	68.8	176.6	112.0	424.0	157.0	334.3	502.3	623.9	1157.9	147.6	39.2	36.0	3779.4
1975	156.3	198.2	158.5	103.2	111.3	264.4	452.5	2202.9	3592.3	1769.5	794.4	453.5	10256.9
1976	625.3	584.1	695.5	544.8	450.2	604.8	1220.4	2811.1	1737.2	665.0	444.8	345.4	10728.7
1977	360.7	319.1	249.2	146.6	272.5	235.5	269.3	127.1	73.1	0.0	0.0	11.5	2064.5
1978	141.0	165.0	211.0	181.0	180.0	521.0	564.0	1154.0	1055.0	729.0	108.0	276.0	5285.0
1979	332.0	230.0	197.0	173.0	277.0	477.0	591.0	1326.0	531.0	39.0	0.0	26.0	4199.0
1980	119.0	151.0	132.0	107.0	194.0	243.0	402.0	1815.0	2802.0	911.0	75.0	281.0	7232.0
1931	427.0	451.0	422.0	289.0	354.0	308.0	527.0	2714.0	1912.0	333.0	57.0	105.0	7899.0
1982	318.0	294.0	247.0	140.0	643.0	490.0	675.0	1406.0	2186.0	996.0	87.0	228.0	7710.0
AVERAGE	282.2	282.2	237.0	208.3	294.5	375.1	564.5	1347.4	1364.1	427.6	113.3	166.2	5662.4
MEDIAN	242.4	273.8	211.0	180.0	257.5	345.7	502.3	1227.7	1323.9	311.9	73.6	137.3	5562.8
80 PERCENTILE	156.3	195.3	139.0	133.6	170.5	243.0	342.7	846.6	528.7	39.0	0.0	36.0	4079.5
60 PERCENTILE	231.9	225.5	179.5	151.1	211.7	291.0	432.0	1128.5	1066.6	225.0	57.0	104.0	5059.4
40 PERCENTILE	304.7	294.0	238.0	230.2	277.0	371.5	564.0	1406.0	1630.1	455.7	84.0	189.0	5932.1
20 PERCENTILE	395.0	353.7	310.0	289.0	442.0	521.2	781.2	1971.5	2105.7	729.0	153.6	281.0	7360.2
MAXIMUM	690.4	584.1	695.5	544.8	800.5	768.2	1303.4	2811.1	3592.3	1769.5	794.4	502.4	10728.7
MINIMUM	68.8	151.0	112.0	103.2	111.3	208.1	202.1	87.1	32.4	0.0	0.0	0.0	1508.6

Clark Fork River

Water available in excess of the low habitat potential instream flow request (200 cfs) near Gold Creek, Water Years 1951-1982.

CLARK FORK WATER AVAILABILITY STUDY
EXCESS FLOW-CLARK FK NR DRUMMOND
(FLOW IN CFS)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOT
1951	655.0	590.0	469.0	369.0	812.0	658.0	1485.0	2751.0	1060.0	1009.0	320.0	476.0	10654.0
1952	807.0	589.0	428.0	395.0	369.0	580.0	1197.0	2320.0	1208.0	241.0	83.0	392.0	3609.0
1953	336.0	344.0	276.0	320.0	460.0	393.0	485.0	1258.0	3614.0	395.0	164.0	260.0	8305.0
1954	295.0	378.0	250.0	269.0	525.0	456.0	795.0	1069.0	1137.0	468.0	175.0	257.0	6074.0
1955	448.0	394.0	298.0	266.0	235.0	357.0	507.0	693.0	1346.0	1986.0	360.0	267.0	7157.0
1956	455.0	411.0	347.0	386.0	351.0	839.0	1111.0	880.0	1613.0	483.0	123.0	160.0	7159.0
1957	444.0	446.0	326.0	226.0	483.0	551.0	547.0	1799.0	623.0	85.0	0.0	205.0	5735.0
1958	311.0	365.0	241.0	228.0	271.0	443.0	663.0	2316.0	439.0	358.0	102.0	267.0	6004.0
1959	394.0	532.0	369.0	458.0	374.0	769.0	1000.0	526.0	2177.0	329.0	145.0	330.0	7403.0
1960	1092.0	870.0	711.0	498.0	513.0	304.0	952.0	1086.0	1656.0	31.0	29.0	295.0	3537.0
1961	343.0	378.0	272.0	246.0	430.0	385.0	361.0	1023.0	698.0	25.0	0.0	124.0	4285.0
1962	401.0	391.0	257.0	242.0	357.0	464.0	1062.0	2023.0	1488.0	697.0	155.0	316.0	7353.0
1963	634.0	583.0	436.0	282.0	845.0	572.0	511.0	1332.0	1943.0	407.0	32.0	336.0	7918.0
1964	452.0	369.0	356.0	259.0	284.0	363.0	607.0	1461.0	3319.0	690.0	349.0	505.0	9014.0
1965	541.0	498.0	417.0	483.0	676.0	559.0	1063.0	2187.0	2598.0	664.0	513.0	853.0	11052.0
1966	684.0	648.0	529.0	432.0	433.0	538.0	616.0	1503.0	656.0	91.0	12.0	117.0	6259.0
1967	323.0	355.0	320.0	289.0	394.0	502.0	620.0	1445.0	2452.0	766.0	192.0	217.0	7875.0
1968	591.0	583.0	404.0	420.0	748.0	780.0	418.0	1277.0	2269.0	274.0	159.0	586.0	8509.0
1969	670.0	605.0	726.0	479.0	407.0	736.0	1723.0	2267.0	438.0	1543.0	208.0	506.0	10308.0
1970	520.0	481.0	500.0	280.0	342.0	432.0	459.0	1347.0	1300.0	650.0	245.0	530.0	7086.0
1971	443.0	509.0	391.0	457.0	1154.0	466.0	678.0	2320.0	1705.0	143.0	162.0	292.0	8720.0
1972	437.0	478.0	261.0	301.0	263.0	1094.0	774.0	1375.0	2025.0	420.0	262.0	450.0	8140.0
1973	414.0	420.0	291.0	325.0	314.0	388.0	329.0	150.0	100.0	0.0	0.0	82.0	2813.0
1974	204.0	343.0	236.0	641.0	296.0	523.0	709.0	767.0	1456.0	260.0	119.0	167.0	5721.0
1975	329.0	373.0	298.0	219.0	235.0	431.0	646.0	2582.0	4389.0	2313.0	1063.0	781.0	13659.0
1976	999.0	909.0	1014.0	800.0	687.0	879.0	1618.0	3281.0	2154.0	915.0	626.0	622.0	14504.0
1977	621.0	541.0	419.0	276.0	450.0	393.0	414.0	196.0	149.0	26.0	0.0	131.0	3616.0
1978	363.0	336.0	346.0	282.0	326.0	727.0	816.0	1330.0	1324.0	949.0	221.0	600.0	7620.0
1979	562.0	431.0	348.0	323.0	518.0	738.0	806.0	1587.0	674.0	115.0	43.0	207.0	6352.0
1980	281.0	312.0	267.0	219.0	299.0	387.0	528.0	2166.0	3424.0	1046.0	127.0	475.0	9531.0
1981	642.0	669.0	626.0	462.0	508.0	475.0	684.0	3071.0	2562.0	539.0	95.0	213.0	10546.0
1982	576.0	571.0	492.0	313.0	956.0	706.0	1040.0	1890.0	2643.0	1381.0	206.0	424.0	11198.0
AVERAGE	508.3	490.8	403.8	357.7	478.6	574.6	788.2	1602.4	1707.5	604.7	196.6	357.6	8070.8
MEDIAN	452.0	478.0	356.0	320.0	430.0	538.0	684.0	1461.0	1656.0	468.0	159.0	316.0	7918.0
80 PERCENTILE	336.0	369.0	272.0	259.0	299.0	393.0	507.0	1023.0	674.0	115.0	32.0	205.0	6074.0
60 PERCENTILE	437.0	411.0	326.0	282.0	369.0	466.0	620.0	1332.0	1346.0	358.0	123.0	267.0	7403.0
40 PERCENTILE	541.0	509.0	404.0	386.0	460.0	572.0	795.0	1799.0	2025.0	650.0	175.0	392.0	8509.0
20 PERCENTILE	642.0	589.0	500.0	462.0	676.0	769.0	1062.0	2316.0	2598.0	949.0	262.0	530.0	10308.0
MAXIMUM	1092.0	909.0	1014.0	800.0	1154.0	1094.0	1723.0	3281.0	4389.0	2313.0	1063.0	853.0	14504.0
MINIMUM	204.0	312.0	236.0	219.0	235.0	357.0	329.0	150.0	100.0	0.0	0.0	82.0	2813.0

Clark Fork River

Water available in excess of the low habitat potential instream flow request (180 cfs) near Drummond, Water Years 1951-1982.

CLARK FORK WATER AVAILABILITY STUDY
EXCESS FLOW-CLARK FK NR CLINTON
(FLOW IN CFS)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOT
1951	657.0	650.3	626.4	411.0	752.7	772.2	1267.1	2938.5	2157.1	1149.6	433.3	627.0	12442.2
1952	680.0	616.4	520.8	348.7	453.4	663.6	1799.0	2469.6	947.2	406.6	134.9	296.0	9336.0
1953	401.0	405.9	403.7	580.9	409.7	475.0	511.9	807.3	3590.2	397.0	174.0	303.0	8459.6
1954	465.0	482.5	446.9	291.7	527.1	553.2	616.1	734.4	805.8	138.7	226.8	275.0	5503.2
1955	397.0	398.1	196.3	225.8	255.9	287.4	674.7	890.1	1191.7	2005.9	283.2	213.0	7019.2
1956	535.0	525.2	1019.0	373.6	243.1	1304.9	1636.3	2691.9	1297.8	531.4	254.1	351.0	10763.2
1957	486.0	536.8	505.4	103.0	444.3	567.0	716.5	1433.7	1162.9	192.5	103.0	277.0	6523.2
1958	560.0	510.6	414.2	343.3	418.8	499.9	749.1	2094.3	1841.8	925.9	197.6	396.0	8951.6
1959	505.0	601.8	649.4	581.8	426.1	822.8	1148.0	974.7	1359.1	97.4	40.2	387.0	7593.5
1960	844.0	864.7	509.3	275.7	458.8	1080.4	1273.6	1264.5	1069.9	140.6	257.7	397.0	8436.2
1961	410.0	508.7	343.2	276.6	493.4	364.6	427.3	702.9	577.0	257.8	0.0	312.0	4673.5
1962	459.0	441.8	277.0	244.5	450.6	670.1	1210.3	1210.5	1115.5	338.4	169.4	345.0	6932.1
1963	542.0	534.9	455.5	142.2	892.0	671.0	835.6	1211.4	1526.5	749.3	147.6	462.0	8169.9
1964	462.0	413.6	222.2	280.1	335.1	391.3	1182.4	1853.1	3120.6	881.8	321.4	594.0	10057.7
1965	578.0	558.2	952.8	861.3	827.4	715.2	1866.9	1908.9	2789.5	1058.4	356.9	1202.0	13675.4
1966	924.0	797.8	570.7	516.0	431.5	767.6	1108.0	242.1	592.8	239.5	91.2	205.0	6486.3
1967	411.0	424.3	348.0	346.0	417.0	503.6	687.7	2167.2	3527.9	814.6	243.1	297.0	10187.3
1968	790.0	754.1	438.2	483.0	975.7	1009.6	882.1	1113.3	1855.8	565.9	400.6	863.0	10131.3
1969	780.0	702.7	528.5	660.2	690.9	935.0	2263.1	1353.6	1233.6	1469.3	236.8	495.0	11348.6
1970	623.0	599.9	448.8	396.7	414.2	433.6	680.2	1884.6	1725.6	1006.6	223.1	428.0	8869.4
1971	722.0	558.2	398.9	512.4	941.1	469.5	465.4	1344.6	1585.1	411.4	103.9	382.0	7894.5
1972	556.0	591.1	510.2	551.6	558.0	1591.0	1215.9	1989.0	2637.0	1174.6	354.2	453.0	12161.6
1973	632.0	595.0	504.5	494.6	373.3	448.4	332.4	329.4	434.7	85.0	0.0	165.0	4394.3
1974	258.0	532.9	373.9	564.9	349.6	585.4	1114.6	1093.5	1583.3	549.6	220.4	295.0	7521.2
1975	442.0	487.4	387.4	329.1	315.9	503.6	816.0	2901.6	4521.1	2448.5	1113.1	971.0	15236.7
1976	1182.0	992.7	1186.1	841.7	664.5	967.2	2016.7	3410.1	2203.6	1088.2	689.0	795.0	16036.8
1977	792.0	641.6	507.4	270.3	430.6	419.8	476.6	252.0	191.1	93.6	4.7	188.0	4267.7
1978	467.0	388.4	533.3	358.4	409.7	994.8	1199.2	1349.1	1207.6	1073.8	367.8	908.0	9257.1
1979	729.0	557.2	490.1	412.7	558.9	891.8	981.6	1672.2	870.9	266.4	98.5	273.0	7802.3
1980	341.0	367.0	320.0	250.0	343.0	444.0	630.0	2429.0	3729.0	1239.0	177.0	564.0	10833.0
1981	781.0	856.0	755.0	559.0	634.0	553.0	785.0	3435.0	2730.0	614.0	185.0	262.0	12149.0
1982	609.0	592.0	545.0	415.0	1142.0	877.0	1152.0	2054.0	2872.0	1623.0	329.0	509.0	12719.0
AVERAGE	592.7	577.7	512.1	415.7	532.4	694.8	1022.5	1631.4	1814.2	751.1	248.1	452.8	9245.5
MEDIAN	560.0	558.2	504.5	396.7	450.6	663.6	981.6	1433.7	1583.3	614.0	223.1	387.0	8951.6
80 PERCENTILE	411.0	441.8	373.9	275.7	373.3	448.4	630.0	890.1	947.2	239.5	103.0	275.0	6932.1
60 PERCENTILE	505.0	532.9	446.9	346.0	426.1	553.0	785.0	1264.5	1233.6	411.4	177.0	312.0	8169.9
40 PERCENTILE	628.0	592.0	509.3	483.0	493.4	715.2	1148.0	1884.6	1841.8	881.8	243.1	428.0	10057.7
20 PERCENTILE	781.0	702.7	570.7	564.9	690.9	967.2	1273.6	2429.0	2872.0	1174.6	354.2	594.0	12149.0
MAXIMUM	1182.0	992.7	1186.1	861.3	1142.0	1591.0	2263.1	3435.0	4521.1	2448.5	1113.1	1202.0	16036.8
MINIMUM	258.0	367.0	196.3	103.0	243.1	287.4	332.4	242.1	191.1	85.0	0.0	165.0	4267.7

Clark Fork River

Water available in excess of the low habitat potential instream flow request (180 cfs) near Clinton, Water Years 1951-1982.

CLARK FORK WATER AVAILABILITY STUDY
EXCESS FLOW-CLARK FK NR TURAH
(FLOW IN CFS)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOT
1951	900.0	822.0	770.0	569.0	1018.0	969.0	2043.0	5779.0	4496.0	2010.0	754.0	835.0	20965.0
1952	959.0	840.0	660.0	505.0	601.0	808.0	2666.0	5138.0	2419.0	946.0	329.0	454.0	16325.0
1953	509.0	515.0	479.0	699.0	545.0	585.0	748.0	1812.0	6876.0	1298.0	461.0	440.0	14967.0
1954	485.0	557.0	529.0	388.0	698.0	688.0	1055.0	2492.0	2663.0	1159.0	505.0	423.0	11642.0
1955	538.0	531.0	289.0	328.0	328.0	364.0	891.0	1943.0	3383.0	3225.0	611.0	348.0	12779.0
1956	631.0	612.0	1143.0	497.0	335.0	1551.0	2545.0	4880.0	3194.0	1081.0	541.0	500.0	17510.0
1957	616.0	667.0	617.0	225.0	585.0	810.0	961.0	3694.0	3091.0	636.0	256.0	382.0	12540.0
1958	659.0	611.0	493.0	432.0	533.0	636.0	1100.0	4305.0	3420.0	1499.0	399.0	509.0	14616.0
1959	629.0	746.0	308.0	736.0	558.0	1087.0	1736.0	2350.0	4010.0	906.0	326.0	590.0	14482.0
1960	1140.0	1072.0	765.0	509.0	615.0	1397.0	1912.0	2664.0	2620.0	528.0	450.0	527.0	14199.0
1961	499.0	659.0	422.0	377.0	654.0	504.0	690.0	2135.0	2247.0	494.0	78.0	419.0	9178.0
1962	606.0	541.0	356.0	325.0	599.0	777.0	2128.0	3170.0	3006.0	913.0	432.0	510.0	13363.0
1963	773.0	708.0	623.0	275.0	1155.0	892.0	1223.0	2855.0	3506.0	1402.0	334.0	588.0	14334.0
1964	575.0	550.0	286.0	387.0	435.0	479.0	1518.0	3685.0	6684.0	1857.0	630.0	814.0	17900.0
1965	754.0	738.0	1094.0	1041.0	1055.0	929.0	2722.0	4248.0	5926.0	2088.0	774.0	1469.0	22838.0
1966	1221.0	951.0	728.0	691.0	569.0	961.0	1609.0	1928.0	1562.0	630.0	217.0	299.0	11366.0
1967	490.0	530.0	421.0	444.0	550.0	669.0	916.0	3427.0	6983.0	1582.0	503.0	413.0	16928.0
1968	959.0	914.0	590.0	680.0	1243.0	1307.0	1187.0	2367.0	4140.0	1127.0	681.0	1097.0	16292.0
1969	1047.0	948.0	671.0	898.0	868.0	1123.0	3235.0	3762.0	2631.0	2521.0	484.0	658.0	18846.0
1970	870.0	715.0	544.0	537.0	553.0	605.0	857.0	3441.0	4358.0	1811.0	500.0	616.0	15407.0
1971	866.0	755.0	494.0	673.0	1287.0	664.0	933.0	4075.0	3848.0	1072.0	327.0	522.0	15516.0
1972	664.0	677.0	604.0	689.0	684.0	1975.0	1748.0	4191.0	6272.0	2033.0	703.0	647.0	20887.0
1973	803.0	728.0	609.0	625.0	475.0	577.0	495.0	1103.0	1207.0	305.0	32.0	261.0	7220.0
1974	333.0	628.0	458.0	844.0	496.0	853.0	1804.0	2824.0	4889.0	1285.0	508.0	436.0	15358.0
1975	555.0	596.0	460.0	437.0	400.0	614.0	1007.0	4183.0	8510.0	4346.0	1756.0	1240.0	24104.0
1976	1536.0	1339.0	1583.0	1177.0	913.0	1265.0	2958.0	7365.0	4991.0	2147.0	1157.0	1019.0	27450.0
1977	967.0	791.0	621.0	383.0	557.0	536.0	707.0	724.0	677.0	268.0	61.0	255.0	6547.0
1978	568.0	496.0	671.0	483.0	524.0	1328.0	1950.0	3242.0	3487.0	2038.0	678.0	1114.0	16579.0
1979	855.0	662.0	585.0	537.0	709.0	1085.0	1283.0	3367.0	2174.0	595.0	274.0	365.0	12491.0
1980	420.0	434.0	417.0	310.0	483.0	537.0	834.0	4902.0	6088.0	1975.0	430.0	678.0	17508.0
1981	881.0	1017.0	902.0	699.0	783.0	695.0	1120.0	5530.0	5085.0	1355.0	377.0	394.0	18838.0
1982	827.0	767.0	666.0	632.0	1414.0	1143.0	1651.0	4306.0	6033.0	2834.0	649.0	732.0	21654.0
AVERAGE	754.2	722.4	636.2	564.1	694.4	887.9	1507.2	3496.5	4077.4	1498.9	506.8	611.1	15957.2
MEDIAN	754.0	708.0	609.0	537.0	599.0	810.0	1283.0	3441.0	3848.0	1355.0	484.0	522.0	15516.0
80 PERCENTILE	538.0	550.0	458.0	383.0	496.0	585.0	891.0	2350.0	2620.0	636.0	326.0	394.0	12540.0
60 PERCENTILE	629.0	659.0	544.0	483.0	557.0	688.0	1100.0	3170.0	3383.0	1127.0	430.0	454.0	14616.0
40 PERCENTILE	827.0	738.0	623.0	632.0	654.0	929.0	1651.0	3762.0	4358.0	1582.0	505.0	590.0	16579.0
20 PERCENTILE	959.0	914.0	765.0	699.0	913.0	1265.0	2128.0	4306.0	6088.0	2088.0	678.0	814.0	18846.0
MAXIMUM	1536.0	1339.0	1583.0	1177.0	1414.0	1975.0	3235.0	7365.0	8510.0	4346.0	1756.0	1469.0	27450.0
MINIMUM	333.0	434.0	286.0	225.0	328.0	364.0	495.0	724.0	677.0	268.0	32.0	255.0	6547.0

Clark Fork River

Water available in excess of the low habitat potential instream flow request (300 cfs) near Turah, Water Years 1951-1982.

CLARK FORK WATER AVAILABILITY STUDY
EXCESS FLOW-CLARK FK NR DEER LODGE
(FLOW IN CFS)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOT
1951	179.0	174.2	131.5	94.5	276.3	205.5	502.6	699.3	241.6	271.8	25.0	95.5	2897.0
1952	244.4	173.7	111.8	107.5	72.5	169.6	334.6	570.0	291.9	0.0	0.0	60.2	2136.4
1953	41.9	61.0	38.9	70.0	114.4	83.6	92.6	251.4	1110.0	38.5	0.0	4.3	1907.1
1954	24.3	76.7	26.4	44.5	144.3	112.6	219.7	194.7	267.8	66.2	0.0	3.5	1130.7
1955	90.0	84.0	49.4	43.0	10.9	67.0	101.7	81.9	338.8	643.1	41.4	7.7	1559.1
1956	93.0	91.9	73.0	103.0	64.3	288.7	349.3	138.0	429.6	71.9	0.0	0.0	1702.7
1957	83.3	108.0	62.9	23.0	125.0	156.3	118.1	413.7	93.0	0.0	0.0	0.0	1188.2
1958	31.1	70.7	22.1	24.0	27.5	106.6	165.6	563.8	30.5	24.4	0.0	7.7	1079.0
1959	66.8	147.5	83.5	139.0	74.8	256.5	303.8	31.8	621.4	13.4	0.0	34.2	1772.3
1960	367.0	303.0	247.7	159.0	138.8	272.6	284.1	199.8	444.2	0.0	0.0	19.5	2435.7
1961	44.9	26.7	37.0	33.0	100.6	79.9	41.8	180.9	118.5	0.0	0.0	0.0	713.3
1962	69.8	32.7	29.8	31.0	67.0	116.2	329.2	480.9	387.1	153.3	0.0	29.3	1775.3
1963	170.0	173.3	115.7	51.0	291.5	165.9	103.3	273.6	541.8	43.1	0.0	36.7	1965.9
1964	91.8	72.5	77.3	39.5	33.4	69.8	142.7	312.3	1009.7	150.6	36.9	107.7	2144.1
1965	130.0	131.9	106.6	151.5	213.8	159.9	329.6	530.1	764.5	140.7	104.1	253.9	3016.6
1966	191.5	200.9	160.3	126.0	102.0	150.3	146.4	324.9	104.2	0.0	0.0	0.0	1506.5
1967	36.3	66.1	60.0	54.5	84.0	133.7	148.0	307.5	714.9	179.5	0.0	0.0	1784.5
1968	151.5	171.0	100.3	120.0	246.9	261.6	65.2	257.1	652.7	0.0	0.0	141.7	2168.0
1969	185.5	181.1	254.9	149.5	90.0	241.4	600.2	554.1	30.1	474.7	0.0	108.1	2369.7
1970	121.0	124.1	146.4	50.0	60.1	101.5	82.0	278.1	323.2	135.4	0.0	113.2	1540.0
1971	87.9	136.9	94.1	138.5	433.6	117.2	171.8	570.0	460.9	0.0	0.0	13.2	2229.1
1972	35.3	122.7	31.7	60.5	23.8	406.0	211.1	236.5	569.7	48.0	1.2	84.6	1931.1
1973	75.4	96.0	46.1	72.5	47.2	81.3	28.7	0.0	0.0	0.0	0.0	0.0	447.2
1974	0.0	60.6	19.7	230.5	39.0	143.4	184.5	104.1	376.2	0.0	0.0	0.0	1157.9
1975	38.9	74.4	49.4	19.5	10.9	101.1	158.7	648.6	1373.5	767.3	329.6	223.6	3795.5
1976	327.0	320.9	393.1	310.0	218.8	307.1	557.2	858.3	613.6	236.1	150.5	156.3	4449.4
1977	164.4	151.7	107.5	48.0	109.8	83.6	63.5	0.0	0.0	0.0	0.0	0.0	728.5
1978	53.5	57.4	72.5	51.0	52.8	237.2	228.4	273.0	331.4	249.0	0.0	147.6	1753.6
1979	128.0	105.0	81.0	48.0	128.0	207.0	173.0	266.0	96.0	0.0	0.0	0.0	1232.0
1980	24.0	56.0	54.0	28.0	82.0	129.0	172.0	539.0	971.0	288.0	0.0	115.0	2458.0
1981	190.0	204.0	173.0	131.0	118.0	119.0	182.0	791.0	719.0	83.0	0.0	1.0	2711.0
1982	118.0	152.0	123.0	36.0	301.0	186.0	242.0	521.0	926.0	413.0	0.0	73.0	3146.0
AVERAGE	116.0	128.4	99.5	88.7	122.0	166.2	215.1	359.6	467.3	140.3	21.5	57.7	1982.2
MEDIAN	91.8	122.7	81.0	70.0	100.6	150.3	173.0	307.5	444.2	66.2	0.0	28.3	1907.1
80 PERCENTILE	41.9	72.5	38.9	39.5	47.2	101.1	101.7	180.9	104.2	0.0	0.0	0.0	1188.2
60 PERCENTILE	85.3	91.9	62.9	51.0	74.8	119.0	158.7	273.0	338.8	24.4	0.0	7.7	1753.6
40 PERCENTILE	121.0	136.9	100.3	103.0	114.4	165.9	211.1	413.7	569.7	135.4	0.0	60.2	2144.1
20 PERCENTILE	185.5	173.7	146.4	139.0	213.8	256.5	329.2	568.8	764.5	249.0	1.2	118.2	2711.0
MAXIMUM	367.0	320.9	393.1	310.0	433.6	406.0	600.2	858.3	1373.5	767.3	329.6	253.9	4449.4
MINIMUM	0.0	56.0	19.7	19.5	10.9	67.0	28.7	0.0	0.0	0.0	0.0	0.0	447.2

Clark Fork River

Water available in excess of the high habitat potential instream flow request (180 cfs) at Deerlodge, Water Years 1951-1982.

CLARK FORK WATER AVAILABILITY STUDY
EXCESS FLOW-CLARK FK NR GARRISON
(FLOW IN CFS)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOT
1951	39.0	28.2	0.0	0.0	221.3	88.5	510.6	880.3	550.6	164.8	0.0	0.0	2483.4
1952	129.4	25.7	0.0	0.0	0.0	59.6	499.6	1149.0	312.9	0.0	0.0	0.0	2177.2
1953	0.0	0.0	0.0	0.0	0.0	0.0	1.6	777.4	2255.0	26.5	0.0	0.0	3060.5
1954	0.0	0.0	0.0	0.0	6.3	0.0	159.7	542.7	450.8	0.0	0.0	0.0	1159.5
1955	0.0	0.0	0.0	0.0	0.0	0.0	0.0	235.9	636.8	588.1	0.0	0.0	1460.8
1956	0.0	0.0	0.0	0.0	0.0	256.7	433.3	1062.0	598.6	0.0	0.0	0.0	2350.7
1957	0.0	0.0	0.0	0.0	0.0	35.3	59.1	1297.7	241.0	0.0	0.0	0.0	1633.0
1958	0.0	0.0	0.0	0.0	0.0	0.0	64.6	943.8	212.5	0.0	0.0	0.0	1220.9
1959	0.0	0.0	0.0	0.0	0.0	129.5	286.8	485.8	1227.4	0.0	0.0	0.0	2129.5
1960	232.0	128.0	101.7	0.0	0.0	235.6	379.1	799.8	515.2	0.0	0.0	0.0	2391.4
1961	0.0	0.0	0.0	0.0	0.0	0.0	0.0	305.9	194.5	0.0	0.0	0.0	500.4
1962	0.0	0.0	0.0	0.0	0.0	0.0	352.2	1157.9	540.1	99.3	0.0	0.0	2149.5
1963	36.0	35.3	0.0	0.0	300.5	51.9	56.3	282.6	714.8	0.0	0.0	0.0	1477.4
1964	0.0	0.0	0.0	0.0	0.0	0.0	77.7	453.3	1781.7	166.6	0.0	0.0	2479.2
1965	0.0	0.0	0.0	19.5	102.8	91.9	386.6	1062.1	1277.5	93.7	0.0	148.9	3183.0
1966	78.5	69.9	75.3	0.0	0.0	85.3	256.4	1096.9	121.2	0.0	0.0	0.0	1783.5
1967	0.0	0.0	0.0	0.0	0.0	0.0	31.0	715.5	1495.9	104.5	0.0	0.0	2346.9
1968	51.5	34.0	0.0	0.0	213.9	231.6	24.2	1007.1	823.7	0.0	0.0	25.7	2411.6
1969	75.5	66.1	111.9	0.0	0.0	208.4	848.2	1477.1	172.1	341.7	0.0	0.0	3301.0
1970	0.0	0.0	0.0	0.0	0.0	0.0	84.0	667.1	515.2	124.4	0.0	0.0	1390.7
1971	0.0	0.0	0.0	0.0	389.6	47.2	159.8	945.0	730.9	0.0	0.0	0.0	2272.5
1972	0.0	0.0	0.0	0.0	0.0	442.0	254.1	779.5	1211.7	0.0	0.0	0.0	2687.4
1973	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1974	0.0	0.0	0.0	128.5	0.0	43.4	187.5	326.1	631.2	0.0	0.0	0.0	1316.7
1975	0.0	0.0	0.0	0.0	0.0	0.0	45.7	1381.6	2956.5	957.3	300.6	111.6	5753.3
1976	236.0	222.9	372.1	225.0	100.8	250.1	823.2	1314.3	911.6	204.1	42.5	22.8	4725.4
1977	30.4	11.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	42.1
1978	0.0	0.0	0.0	0.0	0.0	226.2	322.4	722.0	513.4	224.0	0.0	22.6	2030.6
1979	0.0	0.0	0.0	0.0	0.0	121.0	200.0	795.0	155.0	0.0	0.0	0.0	1271.0
1980	0.0	0.0	0.0	0.0	0.0	0.0	139.0	1065.0	1538.0	295.0	0.0	0.0	3037.0
1981	65.0	104.0	103.0	0.0	52.0	29.0	240.0	2031.0	1151.0	46.0	0.0	0.0	3821.0
1982	0.0	18.0	0.0	0.0	314.0	111.0	291.0	932.0	1416.0	431.0	0.0	0.0	3513.0
AVERAGE	30.4	23.3	23.9	11.7	53.2	85.8	224.2	849.7	811.0	120.8	10.7	10.4	2255.0
MEDIAN	0.0	0.0	0.0	0.0	0.0	47.2	187.5	932.0	636.8	0.0	0.0	0.0	2272.5
80 PERCENTILE	0.0	0.0	0.0	0.0	0.0	0.0	31.0	453.3	212.5	0.0	0.0	0.0	1316.7
60 PERCENTILE	0.0	0.0	0.0	0.0	0.0	0.0	84.0	777.4	540.1	0.0	0.0	0.0	2030.6
40 PERCENTILE	0.0	0.0	0.0	0.0	0.0	85.3	254.1	1007.1	823.7	93.7	0.0	0.0	2391.4
20 PERCENTILE	65.0	35.3	0.0	0.0	100.8	226.2	379.1	1157.9	1416.0	224.0	0.0	0.0	3183.0
MAXIMUM	236.0	222.9	372.1	225.0	389.6	442.0	848.2	2031.0	2956.5	957.3	300.6	148.9	5753.3
MINIMUM	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Clark Fork River

Water available in excess of the high habitat potential instream flow request (400 cfs) at Garrison, Water Years 1951-1982.

CLARK FORK WATER AVAILABILITY STUDY
EXCESS FLOW-CLARK FK NR GOLD CR
(FLOW IN CFS)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOT
1951	184.5	154.4	86.8	17.2	344.0	236.9	915.3	2150.0	629.2	539.3	0.0	46.1	5303.7
1952	290.9	153.7	56.0	37.0	11.8	177.6	637.8	1775.0	752.0	0.0	0.0	0.0	3941.8
1953	0.0	0.0	0.0	0.0	80.0	35.5	125.3	851.1	2749.0	54.3	0.0	0.0	3895.2
1954	0.0	1.8	0.0	0.0	128.7	93.4	370.2	636.6	693.1	111.9	0.0	0.0	2075.8
1955	39.6	13.3	0.0	0.0	0.0	8.1	142.7	359.5	866.6	1311.1	32.0	0.0	2773.0
1956	44.5	25.5	0.0	30.2	0.0	374.4	619.9	522.2	1088.2	123.8	0.0	0.0	2828.7
1957	36.8	50.7	0.0	0.0	97.3	155.6	174.3	1321.7	266.5	0.0	0.0	0.0	2102.9
1958	0.0	0.0	0.0	0.0	0.0	73.5	266.0	1771.5	113.5	25.0	0.0	0.0	2249.5
1959	1.8	112.6	11.8	84.9	15.5	321.2	532.2	214.2	1556.3	2.1	0.0	0.0	2852.6
1960	490.4	356.0	268.8	115.3	119.7	347.3	494.3	701.4	1123.9	0.0	0.0	0.0	4017.1
1961	0.0	1.8	0.0	0.0	57.5	29.4	27.4	646.6	328.7	0.0	0.0	0.0	1091.4
1962	6.7	11.1	0.0	0.0	2.8	89.4	581.2	1516.6	984.4	292.8	0.0	0.0	3485.1
1963	169.8	153.0	62.0	0.0	368.7	171.5	145.9	915.4	1362.1	63.7	0.0	0.0	3412.2
1964	42.4	0.0	2.0	0.0	0.0	12.7	221.7	1027.7	2504.2	287.3	23.2	65.8	4186.9
1965	104.7	88.2	47.8	103.9	242.0	161.6	582.0	1659.3	1905.7	266.8	154.4	302.4	5618.7
1966	204.8	196.2	131.7	65.1	59.8	145.7	228.8	1064.2	293.9	0.0	0.0	0.0	2390.2
1967	0.0	0.0	0.0	0.0	30.5	118.3	232.0	1013.7	1734.6	347.3	0.0	0.0	3526.5
1968	139.7	149.4	38.0	56.0	296.0	329.6	72.4	867.6	1632.7	0.0	0.0	120.9	3702.2
1969	195.0	165.2	279.5	100.8	40.3	296.2	1103.4	1728.9	112.9	961.2	0.0	65.5	5049.3
1970	90.0	75.9	110.0	0.0	0.0	65.1	104.8	928.5	828.4	255.7	0.0	82.8	2541.2
1971	36.1	96.1	28.3	84.1	600.5	91.0	277.8	1775.0	1164.5	0.0	0.0	0.0	4153.4
1972	31.9	73.8	0.0	0.0	0.0	568.2	353.7	952.8	1430.1	74.0	0.0	23.4	3513.0
1973	15.8	32.0	0.0	0.0	0.0	31.7	2.1	0.0	0.0	0.0	0.0	0.0	81.6
1974	0.0	0.0	0.0	224.0	0.0	134.3	302.3	423.9	957.9	0.0	0.0	0.0	2042.3
1975	0.0	0.0	0.0	0.0	0.0	64.4	252.5	2002.9	3392.3	1569.5	594.4	253.5	8129.5
1976	425.3	384.1	495.5	344.8	250.2	404.3	1020.4	2611.1	1537.2	465.0	244.3	145.4	8328.7
1977	160.7	119.1	49.3	0.0	72.5	35.5	69.3	0.0	0.0	0.0	0.0	0.0	506.3
1978	0.0	0.0	11.0	0.0	0.0	321.0	364.0	954.0	855.0	529.0	0.0	76.0	3110.0
1979	132.0	30.0	0.0	0.0	77.0	277.0	391.0	1126.0	331.0	0.0	0.0	0.0	2364.0
1980	0.0	0.0	0.0	0.0	0.0	43.0	202.0	1615.0	2602.0	711.0	0.0	81.0	5254.0
1981	227.0	251.0	222.0	89.0	154.0	108.0	327.0	2514.0	1712.0	133.0	0.0	0.0	5737.0
1982	118.0	94.0	47.0	0.0	443.0	290.0	475.0	1206.0	1936.0	796.0	0.0	28.0	5433.0
AVERAGE	99.6	87.1	60.8	42.3	109.1	175.1	364.5	1153.2	1173.3	278.7	32.8	40.5	3617.1
MEDIAN	42.4	73.8	11.0	0.0	57.5	145.7	302.3	1027.7	1123.9	111.9	0.0	0.0	3513.0
80 PERCENTILE	0.0	0.0	0.0	0.0	0.0	43.0	142.7	646.6	328.7	0.0	0.0	0.0	2249.5
60 PERCENTILE	31.9	25.5	0.0	0.0	11.8	91.0	232.0	928.5	866.6	25.0	0.0	0.0	2852.6
40 PERCENTILE	104.7	94.0	38.0	30.2	77.0	171.5	364.0	1206.0	1430.1	255.7	0.0	0.0	3895.2
20 PERCENTILE	195.0	153.7	110.0	89.0	242.0	321.2	581.2	1771.5	1905.7	529.0	0.0	81.0	5254.0
MAXIMUM	490.4	384.1	495.5	344.8	600.5	568.2	1103.4	2611.1	3392.3	1569.5	594.4	302.4	8328.7
MINIMUM	0.0	0.0	0.0	0.0	0.0	8.1	2.1	0.0	0.0	0.0	0.0	0.0	81.6

Clark Fork River

Water available in excess of the high habitat potential instream flow request (400 cfs) at Gold Creek, Water Years 1951-1982.

CLARK FORK WATER AVAILABILITY STUDY
EXCESS FLOW-CLARK FK NR DRUMMOND
(FLOW IN CFS)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOT
1951	335.0	270.0	149.0	49.0	492.0	338.0	1165.0	2431.0	740.0	689.0	0.0	156.0	6814.0
1952	437.0	269.0	108.0	73.0	49.0	260.0	377.0	2000.0	888.0	0.0	0.0	72.0	5035.0
1953	16.0	24.0	0.0	0.0	140.0	73.0	165.0	938.0	3294.0	75.0	0.0	0.0	4725.0
1954	0.0	53.0	0.0	0.0	205.0	136.0	475.0	749.0	817.0	148.0	0.0	0.0	2598.0
1955	128.0	74.0	0.0	0.0	0.0	37.0	137.0	373.0	1026.0	1666.0	40.0	0.0	3531.0
1956	135.0	91.0	27.0	66.0	31.0	519.0	791.0	560.0	1293.0	153.0	0.0	0.0	3676.0
1957	124.0	126.0	6.0	0.0	163.0	231.0	227.0	1479.0	303.0	0.0	0.0	0.0	2659.0
1958	0.0	45.0	0.0	0.0	0.0	123.0	343.0	1996.0	119.0	38.0	0.0	0.0	2664.0
1959	74.0	212.0	49.0	133.0	54.0	449.0	630.0	206.0	1357.0	9.0	0.0	10.0	3738.0
1960	772.0	550.0	391.0	178.0	193.0	484.0	632.0	766.0	1336.0	0.0	0.0	0.0	5302.0
1961	23.0	58.0	0.0	0.0	110.0	65.0	41.0	703.0	378.0	0.0	0.0	0.0	1378.0
1962	31.0	71.0	0.0	0.0	37.0	144.0	742.0	1703.0	1168.0	377.0	0.0	0.0	4323.0
1963	314.0	268.0	116.0	0.0	525.0	252.0	191.0	1012.0	1623.0	37.0	0.0	16.0	4404.0
1964	132.0	49.0	36.0	0.0	0.0	43.0	257.0	1141.0	2999.0	370.0	29.0	135.0	5271.0
1965	221.0	178.0	97.0	153.0	356.0	239.0	743.0	1867.0	2273.0	344.0	193.0	533.0	7212.0
1966	364.0	328.0	209.0	112.0	113.0	218.0	296.0	1183.0	336.0	0.0	0.0	0.0	3159.0
1967	3.0	35.0	0.0	0.0	74.0	182.0	300.0	1125.0	2132.0	446.0	0.0	0.0	4297.0
1968	271.0	263.0	84.0	100.0	428.0	460.0	98.0	957.0	1949.0	0.0	0.0	266.0	4876.0
1969	350.0	285.0	406.0	159.0	87.0	416.0	1403.0	1947.0	118.0	1223.0	0.0	186.0	6580.0
1970	200.0	161.0	180.0	0.0	22.0	112.0	139.0	1027.0	930.0	330.0	0.0	210.0	3361.0
1971	123.0	189.0	71.0	137.0	834.0	146.0	358.0	2000.0	1385.0	0.0	0.0	0.0	5243.0
1972	117.0	158.0	0.0	0.0	0.0	774.0	454.0	1055.0	1705.0	100.0	0.0	130.0	4493.0
1973	94.0	100.0	0.0	5.0	0.0	63.0	9.0	0.0	0.0	0.0	0.0	0.0	276.0
1974	0.0	23.0	0.0	321.0	0.0	203.0	389.0	447.0	1136.0	0.0	0.0	0.0	2519.0
1975	9.0	53.0	0.0	0.0	0.0	111.0	326.0	2262.0	4069.0	1993.0	743.0	461.0	10027.0
1976	679.0	539.0	694.0	480.0	367.0	559.0	1298.0	2961.0	1334.0	595.0	306.0	302.0	10664.0
1977	301.0	221.0	99.0	0.0	130.0	73.0	94.0	0.0	0.0	0.0	0.0	0.0	918.0
1978	43.0	16.0	26.0	0.0	6.0	407.0	496.0	1010.0	1004.0	629.0	0.0	280.0	3917.0
1979	242.0	111.0	28.0	3.0	198.0	418.0	486.0	1267.0	354.0	0.0	0.0	0.0	3107.0
1980	0.0	0.0	0.0	0.0	0.0	67.0	208.0	1846.0	3104.0	726.0	0.0	155.0	6106.0
1981	322.0	349.0	306.0	142.0	188.0	155.0	364.0	2751.0	2242.0	219.0	0.0	0.0	7038.0
1982	256.0	251.0	172.0	0.0	635.0	386.0	720.0	1570.0	2323.0	1061.0	0.0	104.0	7479.0
AVERAGE	194.2	171.1	101.7	66.5	169.9	254.6	468.2	1291.6	1399.7	352.7	41.0	95.8	4607.2
MEDIAN	132.0	158.0	36.0	0.0	110.0	218.0	364.0	1141.0	1336.0	148.0	0.0	0.0	4404.0
80 PERCENTILE	16.0	49.0	0.0	0.0	0.0	73.0	187.0	703.0	354.0	0.0	0.0	0.0	2664.0
60 PERCENTILE	117.0	91.0	6.0	0.0	49.0	146.0	300.0	1012.0	1026.0	38.0	0.0	0.0	3738.0
40 PERCENTILE	221.0	189.0	84.0	66.0	140.0	252.0	475.0	1479.0	1705.0	330.0	0.0	72.0	4876.0
20 PERCENTILE	322.0	269.0	180.0	142.0	356.0	449.0	742.0	1996.0	2278.0	629.0	0.0	210.0	5590.0
MAXIMUM	772.0	589.0	694.0	480.0	834.0	774.0	1403.0	2961.0	4069.0	1993.0	743.0	533.0	10664.0
MINIMUM	0.0	0.0	0.0	0.0	0.0	37.0	9.0	0.0	0.0	0.0	0.0	0.0	276.0

Clark Fork River

Water available in excess of the high habitat potential instream flow request (500 cfs) at Drummond, Water Years 1951-1982.

CLARK FORK WATER AVAILABILITY STUDY
EXCESS FLOW-CLARK FK NR CLINTON
(FLOW IN CFS)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOT
1951	337.0	330.3	306.4	91.0	432.7	452.2	947.1	2613.5	1837.1	329.6	113.3	307.0	3602.2
1952	360.0	296.4	200.8	23.7	133.4	343.6	1479.0	2149.6	627.2	36.6	0.0	0.0	5705.2
1953	81.0	85.9	83.7	260.9	39.7	155.0	191.9	487.3	3270.2	77.0	0.0	0.0	4732.6
1954	35.0	162.5	126.9	0.0	207.1	233.2	296.1	414.4	485.3	0.0	0.0	0.0	2011.0
1955	77.0	478.1	0.0	0.0	0.0	0.0	354.7	570.1	871.7	1685.9	0.0	0.0	3537.6
1956	215.0	205.2	699.0	53.6	0.0	984.9	1316.3	2371.9	977.8	211.4	0.0	31.0	7066.0
1957	166.0	216.8	185.4	0.0	124.3	247.0	396.5	1113.7	842.9	0.0	0.0	0.0	3292.7
1958	240.0	190.6	94.2	23.3	98.8	179.9	429.1	1774.3	1521.3	605.9	0.0	76.0	5234.0
1959	183.0	231.8	329.4	261.8	106.1	502.3	823.0	654.7	1039.1	0.0	0.0	67.0	4255.9
1960	524.0	544.7	159.3	0.0	138.8	760.4	953.6	944.5	749.9	0.0	0.0	77.0	4852.2
1961	90.0	188.7	23.2	0.0	173.4	44.6	107.3	332.9	257.0	0.0	0.0	0.0	1267.1
1962	139.0	121.8	0.0	0.0	130.6	350.1	890.3	890.5	795.5	18.4	0.0	25.0	3361.2
1963	222.0	214.9	135.5	0.0	572.0	351.0	515.6	891.4	1206.5	429.3	0.0	142.0	4680.2
1964	142.0	93.6	0.0	0.0	15.1	71.3	862.4	1533.1	2800.6	561.8	1.4	274.0	6355.3
1965	258.0	238.2	632.8	541.3	507.4	395.2	1546.9	1533.9	2469.5	738.4	36.9	882.0	9835.4
1966	604.0	477.8	250.7	196.0	111.5	447.6	788.0	0.0	272.8	0.0	0.0	0.0	3148.5
1967	91.0	104.3	28.0	26.0	97.0	183.6	367.7	1847.2	3207.9	494.6	0.0	0.0	6447.2
1968	470.0	434.1	113.2	153.0	655.7	689.6	562.1	793.3	1535.8	245.9	30.6	543.0	6291.3
1969	460.0	332.7	208.5	340.2	370.9	615.0	1943.1	1033.6	913.6	1149.3	0.0	175.0	7591.8
1970	308.0	279.9	128.8	76.7	94.2	113.6	360.2	1564.6	1405.6	686.6	0.0	103.0	5126.2
1971	402.0	238.2	78.9	192.4	621.1	149.5	145.4	1024.6	1265.1	91.4	0.0	62.0	4270.6
1972	236.0	271.1	190.2	231.6	238.0	1271.0	395.9	1669.0	2317.0	354.6	34.2	133.0	3341.6
1973	312.0	275.0	134.5	174.6	53.3	128.4	12.4	9.4	114.7	0.0	0.0	0.0	1264.3
1974	0.0	212.9	53.9	244.9	29.6	265.4	794.6	773.5	1263.3	229.6	0.0	0.0	3867.7
1975	122.0	167.4	67.4	9.1	0.0	183.6	496.0	2581.6	4201.1	2123.5	793.1	651.0	11400.7
1976	862.0	672.7	866.1	521.7	344.5	647.2	1696.7	3090.1	1883.6	768.2	369.0	475.0	12196.8
1977	472.0	321.6	187.4	0.0	110.5	97.8	156.6	0.0	0.0	0.0	0.0	0.0	1348.0
1978	147.0	58.4	213.3	38.4	89.7	674.8	879.2	1029.1	887.6	753.8	47.8	588.0	5417.1
1979	409.0	237.2	170.1	92.7	238.9	571.8	661.6	1352.2	550.9	0.0	0.0	0.0	4284.4
1980	21.0	47.0	0.0	0.0	23.0	124.0	310.0	2109.0	3409.0	919.0	0.0	244.0	7206.0
1981	461.0	536.0	435.0	239.0	314.0	233.0	465.0	3115.0	2410.0	294.0	0.0	0.0	8502.0
1982	289.0	272.0	225.0	95.0	822.0	557.0	832.0	1734.0	2552.0	1303.0	0.0	189.0	8879.0
AVERAGE	274.6	257.7	200.4	121.9	217.0	375.8	702.5	1316.0	1498.2	473.8	46.4	157.8	5642.2
MEDIAN	240.0	238.2	184.5	76.7	130.6	343.6	661.6	1113.7	1263.3	294.0	0.0	67.0	5234.0
80 PERCENTILE	91.0	121.8	53.9	0.0	53.3	128.4	310.0	570.1	627.2	0.0	0.0	0.0	3361.2
60 PERCENTILE	185.0	212.9	126.9	26.0	106.1	233.0	465.0	944.5	913.6	91.4	0.0	0.0	4630.2
40 PERCENTILE	308.0	272.0	189.3	163.0	173.4	395.2	823.0	1564.6	1521.8	561.8	0.0	103.0	6291.3
20 PERCENTILE	461.0	332.7	250.7	244.9	370.9	347.2	953.6	2109.0	2552.0	354.6	34.2	274.0	3341.6
MAXIMUM	862.0	672.7	866.1	541.3	822.0	1271.0	1943.1	3115.0	4201.1	2123.5	793.1	882.0	12196.8
MINIMUM	0.0	47.0	0.0	0.0	0.0	0.0	12.4	0.0	0.0	0.0	0.0	0.0	1264.3

Clark Fork River

Water available in excess of the high habitat potential instream flow request (500 cfs) near Clinton (above Rock Creek), Water Years 1951-1982.

CLARK FORK WATER AVAILABILITY STUDY
EXCESS FLOW-CLARK FK NR TURAH
(FLOW IN CFS)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOT
1951	600.0	522.0	470.0	269.0	718.0	669.0	1743.0	5479.0	4196.0	1710.0	454.0	535.0	17365.0
1952	659.0	540.0	360.0	205.0	301.0	508.0	2366.0	4033.0	2119.0	646.0	29.0	154.0	12725.0
1953	209.0	215.0	179.0	399.0	245.0	285.0	448.0	1512.0	6576.0	998.0	161.0	140.0	11367.0
1954	135.0	257.0	229.0	88.0	398.0	388.0	755.0	2192.0	2363.0	859.0	205.0	123.0	8042.0
1955	238.0	231.0	0.0	28.0	28.0	64.0	591.0	1643.0	3033.0	2925.0	311.0	48.0	9190.0
1956	331.0	312.0	843.0	197.0	35.0	1251.0	2245.0	4580.0	2894.0	781.0	241.0	200.0	13910.0
1957	316.0	367.0	317.0	0.0	285.0	310.0	661.0	3394.0	2791.0	336.0	0.0	82.0	9059.0
1958	359.0	311.0	193.0	152.0	233.0	336.0	800.0	4005.0	3120.0	1199.0	99.0	209.0	11016.0
1959	329.0	446.0	508.0	436.0	258.0	737.0	1436.0	2050.0	3710.0	606.0	26.0	290.0	10832.0
1960	840.0	772.0	465.0	209.0	315.0	1097.0	1612.0	2364.0	2320.0	223.0	150.0	227.0	10594.0
1961	199.0	359.0	122.0	77.0	354.0	204.0	390.0	1335.0	1947.0	194.0	0.0	119.0	5300.0
1962	306.0	241.0	56.0	25.0	299.0	477.0	1828.0	2870.0	2706.0	613.0	132.0	210.0	9763.0
1963	473.0	408.0	323.0	0.0	855.0	592.0	923.0	2555.0	3206.0	1102.0	34.0	288.0	10759.0
1964	275.0	250.0	0.0	87.0	135.0	179.0	1218.0	3335.0	6384.0	1557.0	330.0	514.0	14314.0
1965	454.0	438.0	794.0	741.0	755.0	629.0	2422.0	3948.0	5626.0	1788.0	474.0	1169.0	19238.0
1966	921.0	631.0	428.0	391.0	269.0	661.0	1309.0	1628.0	1262.0	330.0	0.0	0.0	7830.0
1967	190.0	230.0	121.0	144.0	250.0	369.0	616.0	3127.0	6683.0	1282.0	203.0	113.0	13328.0
1968	659.0	614.0	290.0	380.0	943.0	1007.0	887.0	2067.0	3840.0	827.0	381.0	797.0	12692.0
1969	747.0	648.0	371.0	598.0	568.0	323.0	2935.0	3462.0	2331.0	2221.0	184.0	359.0	15246.0
1970	570.0	415.0	244.0	237.0	253.0	305.0	557.0	3141.0	4058.0	1511.0	200.0	316.0	11807.0
1971	566.0	455.0	194.0	373.0	987.0	364.0	633.0	3775.0	3548.0	772.0	27.0	222.0	11916.0
1972	364.0	377.0	304.0	389.0	384.0	1675.0	1448.0	3891.0	5972.0	1733.0	403.0	347.0	17287.0
1973	503.0	423.0	309.0	325.0	175.0	277.0	195.0	803.0	907.0	5.0	0.0	0.0	3927.0
1974	33.0	328.0	158.0	544.0	196.0	553.0	1504.0	2524.0	4589.0	985.0	208.0	136.0	11758.0
1975	255.0	296.0	160.0	137.0	100.0	314.0	707.0	3883.0	8210.0	4046.0	1456.0	940.0	20504.0
1976	1236.0	1039.0	1283.0	877.0	613.0	965.0	2658.0	7065.0	4591.0	1847.0	357.0	719.0	23850.0
1977	667.0	491.0	321.0	83.0	257.0	236.0	407.0	424.0	377.0	0.0	0.0	0.0	3263.0
1978	268.0	196.0	371.0	183.0	224.0	1028.0	1650.0	2942.0	3137.0	1738.0	378.0	814.0	12979.0
1979	555.0	362.0	285.0	237.0	409.0	785.0	983.0	3067.0	1374.0	295.0	0.0	65.0	8917.0
1980	120.0	134.0	117.0	10.0	183.0	237.0	534.0	4602.0	5738.0	1675.0	130.0	378.0	13908.0
1981	581.0	717.0	602.0	399.0	483.0	395.0	820.0	5230.0	4735.0	1055.0	77.0	94.0	15259.0
1982	527.0	467.0	356.0	332.0	1114.0	843.0	1351.0	4006.0	5733.0	2534.0	349.0	432.0	18054.0
AVERAGE	454.2	422.4	337.0	267.2	394.4	587.9	1207.2	3196.5	3777.4	1199.9	234.3	313.7	12392.3
MEDIAN	454.0	408.0	309.0	237.0	299.0	510.0	983.0	3141.0	3548.0	1055.0	184.0	222.0	11916.0
80 PERCENTILE	238.0	250.0	158.0	83.0	196.0	285.0	591.0	2050.0	2320.0	336.0	26.0	94.0	9059.0
60 PERCENTILE	329.0	359.0	244.0	183.0	257.0	388.0	800.0	2870.0	3083.0	827.0	130.0	154.0	11016.0
40 PERCENTILE	527.0	438.0	323.0	332.0	354.0	629.0	1351.0	3462.0	4058.0	1282.0	205.0	290.0	12979.0
20 PERCENTILE	659.0	614.0	465.0	399.0	613.0	965.0	1828.0	4006.0	5738.0	1788.0	378.0	514.0	15246.0
MAXIMUM	1236.0	1039.0	1283.0	877.0	1114.0	1675.0	2935.0	7065.0	8210.0	4046.0	1456.0	1169.0	23850.0
MINIMUM	33.0	134.0	0.0	0.0	28.0	64.0	195.0	424.0	377.0	0.0	0.0	0.0	3263.0

Clark Fork River

Water available in excess of the high habitat potential instream flow request (600 cfs) near Turah (below Rock Creek), Water Years 1951-1982.

307/15

ADDENDUM B

IRRIGATED LAND ASSESSMENT OF THE UPPER CLARK FORK DRAINAGE

February, 1986

Submitted to:
Montana Department of Fish, Wildlife and Parks
1420 East Sixth Avenue
Helena, Montana 59620

Submitted by:
Joe C. Elliott
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TABLE OF CONTENTS

Chapter | Page

I INTRODUCTION 1

II MAPPING OF LANDS 2

- A. Arable Lands 2
- B. Irrigated Lands 2
- C. Irrigable Lands 3
  - 1. Pumping From Rivers 4
    - a. Granite County Data 7
    - b. Cooperative Extension Service Data . . . 11
  - 2. Water Development Projects 15
  - 3. Heavy Metal Constraints 16
  - 4. Potentially Irrigable Lands along Tributary Streams 17

III RESULTS 21

INFORMATION SOURCES

APPENDIX A - PARAMETERS INCLUDED IN MONTANA DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION ANALYSIS

APPENDIX B - PRELIMINARY ECONOMIC ANALYSIS BY GRANITE COUNTY CONSERVATION DISTRICT

APPENDIX C - HEAVY METAL PROBLEMS IN THE DEER LODGE VALLEY

LIST OF FIGURES

Figure Page

1 COST RELATIONSHIPS BETWEEN PUMPING LIFT ELEVATION AND DISTANCE FROM WATER SOURCE FOR A 135-ACRE CENTER PIVOT IRRIGATION SYSTEM 5

2 FLOW DIAGRAM FOR IDENTIFYING IRRIGABLE LANDS 6

LIST OF TABLES

Table		Page
1	PROJECTED COSTS AND CROP VALUES FOR EIGHT-YEAR ROTATION PERIOD	8
2	VARIABLE COSTS ASSOCIATED WITH IRRIGATED ALFALFA PRODUCTION	9
3	FIXED COSTS ASSOCIATED WITH IRRIGATED ALFALFA PRODUCTION IN DEER LODGE VALLEY	10
4	ACREAGE VALUES FOR IRRIGATED AND IRRIGABLE LANDS IN THE UPPER CLARK FORK DRAINAGE BASED ON GRANITE COUNTY DATA	13
5	ACREAGE VALUES FOR IRRIGATED AND IRRIGABLE LANDS IN THE UPPER CLARK FORK DRAINAGE BASED ON COOPERATIVE EXTENSION SERVICE DATA	14
6	POTENTIALLY IRRIGABLE ACREAGE ALONG TRIBUTARIES OF THE LITTLE BLACKFOOT RIVER	19
7	POTENTIALLY IRRIGABLE ACREAGE ALONG TRIBUTARIES OF FLINT CREEK	20

I. INTRODUCTION

The Montana Department of Fish, Wildlife and Parks (DFWP) is preparing a water reservation request for the upper Clark Fork drainage to be submitted to the Montana Department of Natural Resources and Conservation (DNRC) for review and analysis. One aspect of the water reservation request concerns the status of irrigated land and potentially irrigable land within the upper Clark Fork Valley.

This report discusses the methods used to identify potentially irrigable land and presents acreage figures for irrigated and irrigable land in the upper Clark Fork Valley. Constraints to irrigation imposed by economics and heavy metals are discussed and reflected in the data presented. No attempt was made to project how future costs may alter economic feasibility or how future reclamation activities may ameliorate heavy metal toxicity problems. In addition, the critical question of if and where water may be available for expanding irrigation in the upper Clark Fork drainage was not addressed.

II. MAPPING OF LANDS

A. Arable Lands

Arable lands are those lands which have suitable soil, climatic, and topographic features for supporting sustained crop production. Arable lands only become "irrigable" when water is available and can be supplied and applied cost effectively.

Arable lands that are not currently being irrigated were mapped utilizing aerial photographs upon which soil mapping units had been delineated by the Soil Conservation Service (SCS). Photocopies were made of the aerial photographs while visiting SCS offices in Deer Lodge and Philipsburg. Composite working maps were constructed by taping the photocopies together along the match lines as delineated on the aerial photographs.

Based on capability classes and soil correlations provided by the SCS, all lands that were Class I, II, III, or IV were identified and shaded in on the composite working maps. These lands can sustain irrigated agriculture, but have certain limitations that must be considered by agriculturists.

B. Irrigated Lands

The status of irrigated lands in the upper Clark Fork Valley was determined by relying upon existing data, photointerpretation, field reconnaissance, aerial observation, and limited aerial imagery recorded on a video cassette. The State Engineer's Office has assembled existing data on irrigated lands in the form of a "Water Resources Survey" for each Montana county. Each survey includes maps showing irrigated lands, irrigation ditches, and other pertinent features. Because, however, the

Water Resources Surveys were compiled in the 1950s and 1960s, the mapping of irrigated lands is not current.

Updating the mapping of irrigated land acreages was accomplished by comparing SCS aerial photographs with the Water Resources Survey data base. Lands which appeared to be irrigated on aerial photographs, but which were not mapped on Water Resources Surveys, were added to the irrigated land base map. A constraint to updating irrigated land acreages by aerial photointerpretation was that the aerial photographs for Granite County were taken in 1965, whereas the aerial photographs for Deer Lodge and Powell counties were taken in 1976. Because the photographs were not taken at the same time, consistent updating was not possible using aerial photographs.

Additional irrigated lands were identified and mapped through direct aerial observation. A helicopter flight over the study area was made on August 3, 1984. The flight was made during the peak of the irrigation season; therefore, irrigated lands contrasted with the dessicated adjacent rangeland.

On July 18, 1985, aerial imagery was acquired on a video cassette recorder (LMS system) for irrigated lands northwest of Deer Lodge. Because it was apparent that new pivot systems had been added during the course of this study, the imagery was used with the LMS system at the DNRC to update the mapping of irrigable lands.

C. Irrigable Lands

Irrigable lands were identified and delineated on base maps after economic and heavy metal toxicity constraints were considered. Economic constraints were developed based on the assumption that water would either have to be pumped from an existing river or large stream or supplied from reservoirs not yet constructed. Heavy metal constraints were based on data which identified areas where waterborne mine tailings have been deposited on the floodplain of the Clark Fork River.

1. Pumping From Rivers

The economics of pumping irrigation water from the Clark Fork and major tributaries (i.e., Little Blackfoot and Flint Creek)[1] were considered based on a computer analysis using the Soil Conservation Service IRRSYS model. After updating costs of commodities such as electricity, pipes, and pumps (see Appendix A for the parameters included in the analysis), costs for supplying water, as a function of pumping lift elevation, distance, and acreage, were calculated. By varying pump lift elevation, distance, and acreage, a matrix was constructed (Figure 1) which shows the relationships among these variables.

Based on the data generated from the IRRSYS model, costs associated with construction and operation of irrigation systems have been determined. These costs, however, do not include the cost of planting, managing, and harvesting the crop. In order for irrigation to be economically feasible, the value of the crop must offset the cost of supplying water (i.e., IRRSYS model values). Figure 2 is a flow diagram showing how the IRRSYS model used in conjunction with other information was used to identify potentially irrigable lands.

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[1] Only the Clark Fork and major tributaries were considered in the analysis because, based on field observations, tributary streams appear to be maximally utilized as irrigation sources at the present time. Also, it was believed that for the cost of installing a sprinkler irrigation system to be justified, a reliable source of water would be necessary throughout the growing season. The smaller tributary streams probably would not consistently provide water during dry years.

FIGURE 1

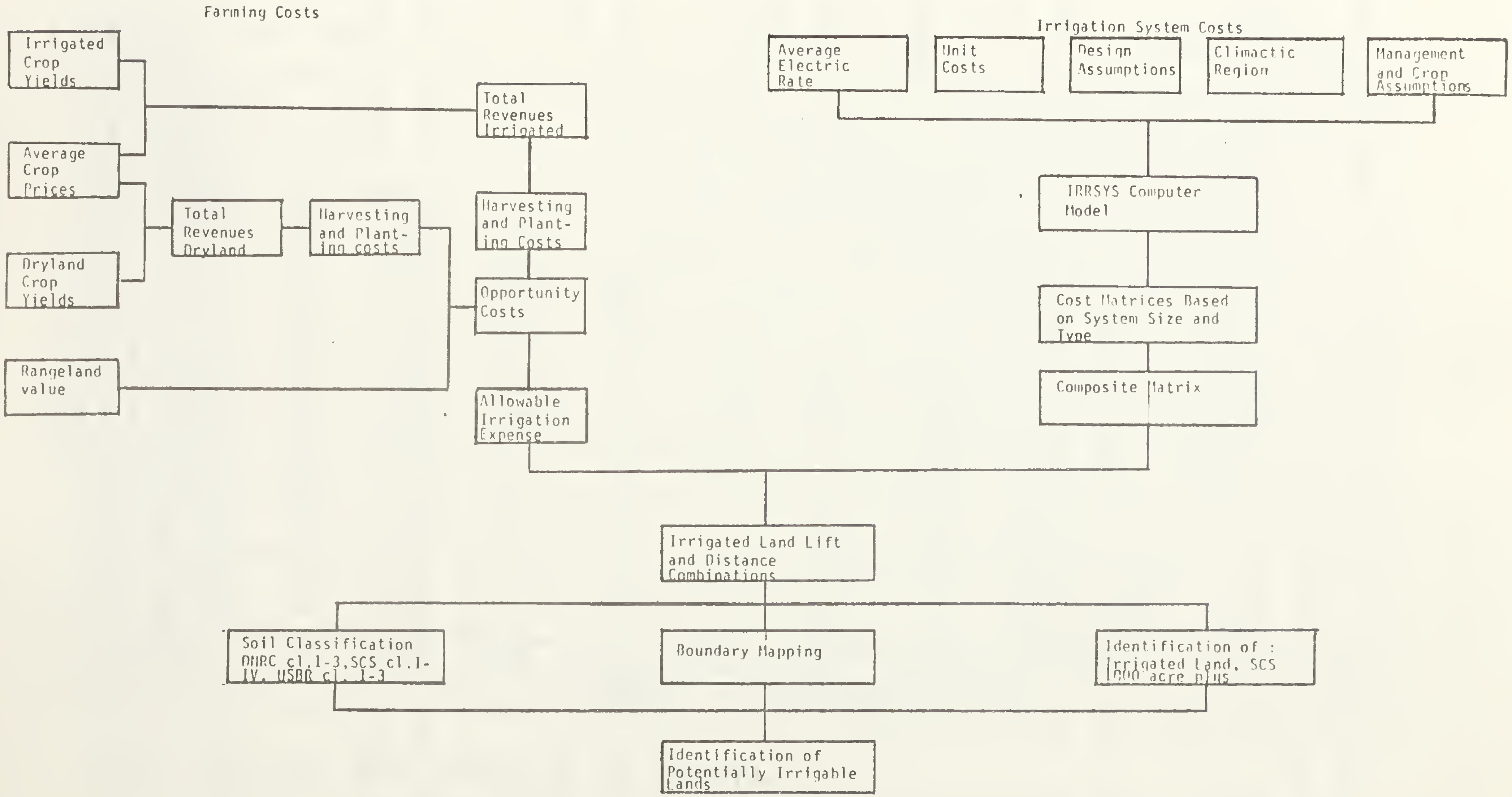
COST RELATIONSHIPS BETWEEN PUMPING LIFT ELEVATION AND DISTANCE FROM WATER SOURCE FOR A 135-ACRE CENTER PIVOT IRRIGATION SYSTEM

Values are costs in dollars —

Distance (Miles)	Pumping Lift Elevation (Feet)											
	40	80	120	160	200	240	280	320	360	400	440	480
.1	76	88	100	112	124	136	150	162	176	188	201	
.3	80	92	105	117	133	146	158	169	188	201		
.5	85	99	112	124	138	152	165	176	199			
.7	90	104	118	130	144	159	171	182	210			
.9	95	109	124	139	151	166	178	210				
1.1	100	115	130	146	159	171	183	221				
1.3	104	120	135	153	165	178	190	231				
1.5	113	130	141	158	173	186	198					
2.0	126	143	162	175	189	202						
2.5	145	166	178	194	206							
3.0	159	183	184	210								
3.5	185	198										
4.0	202											
4.5												
5.0												
5.5												

FIGURE 2

FLOW DIAGRAM FOR IDENTIFYING IRRIGABLE LANDS


Farming Costs
Irrigated Crop Yields
Average Crop Prices
Dryland Crop Yields
Rangeland value
Total Revenues Dryland
Harvesting and Planting costs
Total Revenues Irrigated
Harvesting and Planting Costs
Opportunity Costs
Allowable Irrigation Expense
Irrigation System Costs
Average Electric Rate
Unit Costs
Design Assumptions
Climactic Region
Management and Crop Assumptions
IRRSYS Computer Model
Cost Matrices Based on System Size and Type
Composite Matrix
Irrigated Land Lift and Distance Combinations
Soil Classification DNRC cl.1-3, SCS cl.I-IV, USBR cl. 1-3
Boundary Mapping
Identification of : Irrigated Land, SCS 1000 acre plus
Identification of Potentially Irrigable Lands

The IRRSYS model provided costs only for construction and operation of the irrigation system; therefore, it was necessary to obtain additional cost information for planting, managing, and harvesting crops. Two sources of this information were used to compute fixed and variable enterprise costs. The Granite County Conservation District provided enterprise costs for two farmers in the Deer Lodge Valley (Appendix B), and the Cooperative Extension Services (1980) compiled enterprise costs for six farmers in the Deer Lodge Valley.

Table 1 shows the projected costs and crop values based on the Granite County Conservation District data. Tables 2 and 3 show variable and fixed costs, respectively, for irrigated alfalfa production based on Cooperative Extension Service data. Based on Granite County data, the cost per acre would be $67.75, whereas costs based on the Cooperative Extension Service data would be $93.14 per acre. Both of these cost values were used in conjunction with data from the IRRSYS model to determine acreages of irrigable land within economically acceptable cost limits.

a. Granite County Data

Based on the assumption that alfalfa would be grown from seven out of eight years and that small grains would be grown for the first planting season, cost estimates were derived for an eight-year period using the Granite County data. During the first year, the native range would be plowed and planted to spring wheat and would be expected to yield approximately 60 bushels per acre.[2] The average cost for plowing, planting,

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[2] This yield estimate was provided by Jerry Schaefer, Economist, Soil Conservation Service, Bozeman, Montana.

TABLE 1

PROJECTED COSTS AND CROP VALUES FOR EIGHT-YEAR ROTATION PERIOD

Year	Cost/Acre	Yield/Acre	Price[1]	Value/Acre[2]
1	\$ 78.42	60 bu.[3]	\$3.89/bu.	\$233.40
2	\$109.42	4 tons	\$68/ton	\$272.00
3	\$ 59.03	4 tons	\$68/ton	\$272.00
4	\$ 59.03	4 tons	\$68/ton	\$272.00
5	\$ 59.03	4 tons	\$68/ton	\$272.00
6	\$ 59.03	4 tons	\$68/ton	\$272.00
7	\$ 59.03	4 tons	\$68/ton	\$272.00
8	\$ 59.03	4 tons	\$68/ton	\$272.00
Average	\$ 67.75			\$267.18

---

[1] These prices are based on an 5.5 year average for spring wheat and alfalfa, adjusted to May 1984 dollar values (Kangas 1984).

[2] This value does not consider installation costs for the sprinkler system.

[3] This value was provided by Jerry Schaefer, Economist, Soil Conservation Service, Bozeman, Montana (October 1984).

TABLE 2

VARIABLE COSTS ASSOCIATED WITH IRRIGATED ALFALFA PRODUCTION

Variable Costs	Cost/Acre
Pre-Harvest Costs	
Twine	\$ 5.28
Miscellaneous	\$ 7.08
Management	\$ 6.00[1]
Automobile	\$ .45
Machinery	\$ 4.80
Tractors	\$ 1.53
Labor (Tractor & Machinery)	\$ 5.70
Labor (Irrigation)	\$ 3.75
Interest on Operating Capital	\$ .44
Subtotal	\$35.03
Harvest Costs	
Machinery	\$12.33
Tractors	\$ 3.77
Labor	\$ 6.42
Subtotal	\$22.52
Total Variable Costs	\$57.55

[1] Estimated cost differs from Cooperative Extension Service value.

Source: Cooperative Extension Service Bulletin 1244, "Enterprise Costs in Deer Lodge Valley," 1985.

TABLE 3

FIXED COSTS ASSOCIATED WITH IRRIGATED ALFALFA PRODUCTION IN DEER LODGE VALLEY

Variable	Depreciation	5% Real Interest	Machine Taxes	Insurance
Tractor	$ 795.00	$ 728.75	$ 280.57	$ 33.52
Pickup	$2,520.00	$ 385.00	$ 148.22	$ 17.71
Bale Wagon	$3,537.00	$1,801.25	$ 693.48	$ 82.86
Swather	$1,512.00	$ 770.00	$ 296.45	$ 35.42
Roller Packer	$ 243.00	$ 206.25	$ 79.41	$ 9.49
Baler PTO	$ 900.00	$ 343.75	$ 132.34	$ 15.81
Total	$9,507.00	$4,235.00	$1,630.~~00~~ 47	$194.81

15,574.67 + 7.39 =

Total of Above Columns = $15,~~566.81 + $7.~~39 = $15,574.20

Prorated Establishment Cost for Nurse Crop = $47.86[1] amortized every 8 years for 49 years equals $7.39/year

575

Total Fixed Costs are $15,~~574~~.00 per year.
Assuming a 500-acre farm, the costs are:

Cost Per Acre	$31.15
Total Variable Costs	57.55
Total Costs	$88.70 x 1.05[2] = $93.14

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[1] Based on "Enterprise Costs in Deer Lodge Valley," Cooperative Extension Service, Bozeman, Montana. Bulletin 1244, November 1980.

[2] Conversion from November 1980 value to July 1985 value. Based on Economic Indicators, March 1985, Council of Economic Advisors.

Source: John Tubbs, Economist, Montana Department of Natural Resources and Conservation, Helena, Montana; and Montana Cooperative Extension Service.

and harvesting would be approximately $78.42[3] per acre. This value does not include the cost of installing and operating an irrigation system.

The second year alfalfa hay would be established at an approximate cost of $109.42 per acre, excluding the cost of installation and operation of the irrigation system. During years three through eight, alfalfa management and harvesting would cost approximately $59.03 per acre annually. Based on the values presented in Table 1, the average cost per year after the eight-year rotation period for planting and harvesting the crop would be $67.75 per acre.

The average value of the crop over an eight-year period was estimated to be $267.18[4] per acre. In order for irrigation to be economically feasible, water would have to be delivered at a cost of less than $195.68 per acre ($267.18 - $67.75 - $3.75).

3.75 = value of 1acre native rangeland for livestock grazing

Table 4 shows the acres of irrigable land that could be served assuming that water could be delivered for $195.68 or less per acre. These values do not reflect whether sufficient water is available to serve these lands. Downstream water rights or physical unavailability of water during the irrigation season may limit irrigation service to these lands.

b. Cooperative Extension Service Data

Based on cost enterprise studies in the Deer Lodge Valley (Tables 2 and 3), and assuming that alfalfa would be grown 7 out of 8 years with a small grain nurse crop being grown every eighth year, costs and benefits were computed. The same assumptions concerning yield and crop value were applied for both Granite County and Cooperative Extension Service data. Benefits for Extension Service data were amortized, however, over a 49-year period (i.e., $260.60 per acre[5]) and fixed costs were calculated assuming a 500-acre operation.

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[3] This value and other values presented an average reported by two representative landowners in the Flint Creek Valley.

[4] The value of the crop is $267.18; $67.75 is the cost of planting, managing, and harvesting; $3.75 is the present value of the grazing land that would be lost.

In order for irrigation to be economically feasible, water would have to be delivered at $163.77 or less per acre ($260.60 - $93.14 - $3.75). Utilizing cost relationships of various pumping lift and distance combinations in the IRRSYS model (Figure 1), water could be supplied within the limits of economic feasibility at the following pumping lift elevations and distances:

Elevation (Feet)	Distance (Miles)
40	3.0
120	2.0
160	1.5
200	1.1
240	0.5
280	0.3
320	0.1

Table ~~4~~ 5 shows the acreages of land that could be economically served if water could be supplied at $163.77 per acre. It can be seen by comparing irrigated land acreages in Tables 4 and 5 that a cost increase of $25.39 per acre ($71.50 increased to $96.89) results in a change in irrigable acreage from 15,753 acres to 7,842 acres. This cost increase of 36 percent results in an acreage reduction of 50 percent.

The reason a 36 percent increase in cost results in 50 percent reduction in acreage is directly related to the topography of the upper

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[5] This information was provided by John Tubbs, Economist, Montana Department of Natural Resources and Conservation, Helena, Montana.

TABLE 4

ACREAGE VALUES FOR IRRIGATED AND IRRIGABLE LANDS IN THE UPPER CLARK FORK DRAINAGE BASED ON GRANITE COUNTY DATA

See explanation on errata –

River Reach	Irrigated Acres	Irrigable Acres
Clark Fork (Bonner-Rock Creek)	1,708	480
Clark Fork (Rock Creek-Drummond)	2,236	411
Clark Fork (Drummond-Gold Creek)	2,841	3,863
Perkins Creek	34	--
Clark Fork (Gold Creek-Garrison)	483	1,447
Gold Creek	1,506	--
Warm Springs Creek	52	--
Carten Creek	19	--
Clark Fork (Garrison-Deer Lodge)	2,992	3,456
Mullan Gulch	1,571	--
Willow Creek	553	--
Clark Fork (Deer Lodge-Warm Springs)	6,185	2,042
Warm Springs Creek	1,255	--
Lost Creek	4,572	--
Race Track Creek	8,155	--
Caribou Creek	1,507	--
Peterson Creek	1,046	
Dempsey Creek	1,727	--
Cottonwood Creek	926	--
Fred Burr Creek	4,602	--
Tin Cup Joe Creek	1,109	--
LaMarche Creek	3,196	--
Barker Creek	--	--
Twin Lakes Creek	--	--
Flint Creek (Drummond-Maxville	7,295	1,317
Willow Creek	5,983	--
Flint Creek (Maxville-Georgetown Lake)	9,698	912
North Fork Flint Creek	5	--
Silver Creek	20	--
Boulder Creek	--	--
Little Blackfoot (Garrison-Headwaters)	4,265	1,825
Dog Creek	447	--
Snowshoe Creek	758	--
Trout Creek	604	--
Carpenter Creek	532	--
Six Mile Creek	4,137	--
Total	82,019	15,753

TABLE 5

ACREAGE VALUES FOR IRRIGATED AND IRRIGABLE LANDS IN THE UPPER CLARK FORK DRAINAGE BASED ON COOPERATIVE EXTENSION SERVICE DATA

See explanation on errata
does not include irrigable acreage along CF tributaries,
Little Blkfoot, Flint Creek.

River Reach	Irrigated Acres	Irrigable Acres
Clark Fork (Bonner-Rock Creek)	1,708	348
Clark Fork (Rock Creek-Drummond)	2,236	268
Clark Fork (Drummond-Gold Creek)	2,841	963
Perkins Creek	34	--
Clark Fork (Gold Creek-Garrison)	483	195
Gold Creek	1,506	--
Warm Springs Creek	52	--
Carten Creek	19	--
Clark Fork (Garrison-Deer Lodge)	2,992	2,976
Mullan Gulch	1,571	--
Willow Creek	553	--
Clark Fork (Deer Lodge-Warm Springs)	6,185	1,248
Warm Springs Creek	1,255	--
Lost Creek	4,572	--
Race Track Creek	8,155	--
Caribou Creek	1,507	--
Peterson Creek	1,046	
Dempsey Creek	1,727	--
Cottonwood Creek	926	--
Fred Burr Creek	4,602	--
Tin Cup Joe Creek	1,109	--
LaMarche Creek	3,196	--
Barker Creek	--	--
Twin Lakes Creek	--	--
Flint Creek (Drummond-Maxville	7,295	360
Willow Creek	5,983	--
Flint Creek (Maxville-Georgetown Lake)	9,698	442
North Fork Flint Creek	5	--
Silver Creek	20	--
Boulder Creek		
Little Blackfoot (Garrison-Headwaters)	4,265	1,042
Dog Creek	447	--
Snowshoe Creek	758	--
Trout Creek	604	--
Carpenter Creek	532	--
Six Mile Creek	4,137	--
Total	82,019	7,842

Clark Fork drainage. Arable lands that are not currently being irrigated lie on terraces a mile or more from the Clark Fork River. The increased costs reduce the economic feasibility of providing water to these terraces and thereby reduce the irrigated acreage by an apparently disproportionate amount.

2. Water Development Projects

The Granite County Conservation District is currently studying dam sites for possible water developments in the Flint Creek Valley. One site is on Boulder Creek near Princeton and another site is on the North Fork of Willow Creek above the existing Willow Creek Reservoir. Both sites would provide gravity feed irrigation water to areas that are not currently being irrigated. The Boulder Creek project would allow 5,000 acres to be converted from rangeland to cropland, whereas the Willow Creek project would expand the irrigated land base by 2,000 acres.

Although the final economic analyses of these water development projects have not been completed by the Granite County Conservation District and the SCS, some preliminary economic information is available. Based on the projected benefits of the project, irrigation water would have to be delivered at $38.21 per acre-foot to provide a favorable benefit/cost ratio.

As previously stated, final economic information is not yet available on the projects, particularly in regard to costs of water delivery. In the absence of such information, data on water delivery costs compiled by Finnie (1984) were reviewed. Based on information presented by Finnie, non-subsidized project costs typically run $50.00 per acre-foot for repairing or retrofitting existing water impoundments and between

$150.00 and $300.00 per acre-foot for building new storage capacity. If Finnie's projected cost estimates are anywhere near correct, the cost of delivering water from the proposed Boulder Creek and Willow Creek projects would be prohibitive.

3. Heavy Metal Constraints

Contamination of soils by heavy metals in the upper Clark Fork drainage is a problem which limits the productive potential of some lands and may seriously impair water quality. Airborne heavy metal particulates have been emitted from the Anaconda Smelter since the late 1800s and have settled on land in the Deer Lodge Valley. Additionally, waterborne mine tailings with heavy metal concentrations have contaminated floodplain soils and some agricultural land in close proximity to the Clark Fork River. Heavy metals in soils impose constraints on various land uses including irrigated agriculture. A discussion of studies which have addressed the heavy metal problems in the Deer Lodge Valley and the riverine ecosystem downstream is presented in Appendix C.

Taking into account the constraints that heavy metals impose on irrigated agriculture, no lands were considered potentially irrigable if they occurred on the floodplain between Anaconda and Drummond. Because tailings have been deposited at least as far downstream as Drummond, agricultural activities on the floodplain along this reach of the river could mobilize heavy metals and increase contamination of the Clark Fork River.

Arable lands were considered to be potentially irrigable if they occurred on the floodplain between Drummond and Bonner. Although heavy metals may be present along this reach of the river, there are no "slickens" areas which are readily apparent. Also, there are no reports that heavy metals have affected agricultural activities along this reach of the Clark Fork.

4. Potentially Irrigable Lands Along Tributary Streams

Although streamflow data are not available for most tributary streams of the upper Clark Fork River, potentially irrigable lands along tributary streams was analyzed. Consideration of terrain, federal landownership, and the location of arable lands in relation to the tributaries were factors in determining that the greatest potential for irrigation was in the Flint Creek and Little Blackfoot watersheds.

The potential for irrigation from tributaries of the Clark Fork between Garrison and Bonner is virtually nonexistent. Most of the tributaries drain very steep terrain and have limited drainage areas. It is improbable that these streams could reliably provide irrigation water 8 out of 10 years. In addition, much of the land drained by these streams is administered by the U.S. Forest Service or the U.S. Bureau of Land Management, thereby making the land unavailable for development of irrigated agriculture.

Potentially irrigable lands along the tributaries of the Little Blackfoot and Flint Creek were determined using the same economic criteria that were used to identify irrigable lands along the mainstem Clark Fork and Little Blackfoot. The only difference in the analysis was that arable lands adjacent to tributaries of the Little Blackfoot were identified ~~for~~ from maps constructed by the Water Resources Division of the DNRC. Because the soil survey was not complete in the upper Little Blackfoot watershed, it was necessary to rely upon the less detailed Water Resources survey of arable lands for the basis of determining potential irrigability based on the economic feasibility.

Without considering whether the tributary streams would have sufficient summer streamflows to reliably provide water to the potentially irrigable lands, 5,765 acres of potentially irrigable land were identified along the tributaries of the Little Blackfoot (Table 6) and 3,477 acres were identified along the tributaries of Flint Creek (Table 7).

TABLE 6

POTENTIALLY IRRIGABLE ACREAGE ALONG TRIBUTARIES OF THE LITTLE BLACKFOOT RIVER

Tributary Stream	Acres
Spotted Dog Creek	480
Trout Creek	576
Telegraph Creek	467
Snowshoe Creek	1,094
Carpenter Creek	518
Six Mile Creek	806
Gimlet Creek	557
Three Mile Creek	1,267
Total	5,765

from cost data supplied by Coop Ext. SERVICE

See explanation - errata Sheet

TABLE 7

POTENTIALLY IRRIGABLE ACREAGE ALONG TRIBUTARIES OF FLINT CREEK

Tributary Stream	Acres
Henderson Creek	446
South Fork Lower Willow Creek	182
West Fork Lower Willow Creek	142
Lower Willow Creek	179
Cow Creek	2,203
Marshall Creek	325
Total	3,477

III. RESULTS

Acreages of irrigated and irrigable lands within the upper Clark Fork drainage are presented for various river reaches in Tables 4 and 5, 6 & 7. Only those irrigable acreages capable of being served economically by pumped irrigation water are shown. Economic feasibility has been determined by relying upon the cost values shown in the IRRSYS matrix (Figure 1). opportunity cost (eg 3.75 for value of range land) & EXPECTED crop revenues.

Land acreages that would be irrigable with the construction of water impoundments are not presented. At this time, the benefit/cost ratio of supplying water through new storage facilities does not appear to be favorable. However, data being compiled by the Granite County Conservation District may require additional study to determine the economics of potential water development projects.

In general, the acreages of irrigable lands in the upper Clark Fork Valley occur on the terraces above the floodplain from 3/4 to 1 1/2 miles from the Clark Fork or a major tributary. Because of the distance from the water source and relatively high pumping lift elevation, most of the potentially irrigable land is economically marginal to irrigate. Probably because of the marginal benefit/cost status, very little land is irrigated by pumping directly from the Clark Fork or a major tributary. Most terraces or benches that are now being irrigated are provided with gravity-feed irrigation water supplied from tributary drainages that have been diverted at higher elevations.

INFORMATION SOURCES

INFORMATION SOURCES

Cooperative Extension Service. 1980. Enterprise Costs in Deer Lodge Valley. Montana State University Bulletin 1244.

Elliott, J. 1984. Irrigated Land Assessment of the Upper Clark Drainage, Interim Report. Unpublished report submitted to the Montana Department of Fish, Wildlife and Parks, Helena, Montana.

Finnie, B. 1984. Elements of a Water Marketing Program. Written transcript of a speech presented to the Montana Environmental Council meeting in Billings, Montana (July 13, 1984), by Bruce Finnie of ECO Northwest Ltd., Helena, Montana.

Kangas, A. 1984. Economic data compiled by Arlen Kangas of the Montana Department of Natural Resources and Conservation, Helena, Montana.

Schaefer, J., Economist, Soil Conservation Service, Bozeman, Montana. Personal communication (October 2, 1984) to Joe C. Elliott, Ecological Consultant, Helena, Montana.

APPENDIX A

PARAMETERS INCLUDED IN MONTANA DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION ANALYSIS

ANNOTATED DESCRIPTION OF IRRSYS INPUTS[1]

Percent of Alfalfa: 100%

A crop composition of 100 percent alfalfa is assumed since alfalfa is one of the most water intensive crops grown in the state. The system design that will meet the consumptive demands of alfalfa will also be capable of meeting the requirements of other crop mixes. This assumption, however, results in a slight over estimation of annual costs. This over estimation is mainly a result of exaggerated electric costs over the project life. The model forecasts equal annual energy demands needed to meet the consumptive needs of alfalfa. However, annual electric demand will drop, even assuming 100 percent alfalfa, in years when, for agronomic reasons, the ground is fallow or planted with a crop with lower water needs.

Peak Use: (variable) Average Annual Use: (variable)

These variables are dependent upon which climatic region the acreage being analyzed is located. The USDA-SCS has identified five climatic regions in the state.

Percent Sprinkler Acreage: 100%

All irrigated acreage is assumed to be sprinkler irrigated with no flood irrigation.

Average Irrigation Efficiency: 70% (center pivot) or 65% (wheel line)

This efficiency represents the average amount of water applied by an on-farm irrigation system that is consumed by the crop divided by the total amount applied. The unconsumed portion accounts for water losses due to deep percolation, evaporation, and return flow. These percentages were provided by the USDA-SCS staff in Bozeman.

---

[1] Source: John Tubbs, Economist, Montana Department of Natural Resources and Conservation, Helena, Montana.

Maximum Net Application: 2 inch (center pivot),
3 inch (wheel line)

Maximum net application represents the amount of water needed to be placed in the soil by an irrigation system to meet crop water requirements. These application amounts represent the typical Montana farm and were provided by the USDA-SCS staff.

Average Pumping Head: (variable)

Average pumping head refers to the amount of pressure needed to compensate for friction loss in the irrigation system. Friction losses were calculated using the Hazen-Williams equation.

Peak Management Efficiency: 95%
Seasonal Management Efficiency: 85%

These efficiencies were recommended by the USDA-SCS staff as representative of a well managed irrigation system.

Storage Costs: 0

No storage costs were added to system costs, therefore, costs are slightly understated over the project life. A 10 percent contingency factor was included to compensate for this type of under estimation.

Additional Costs: (variable)

No additional costs were added when the system being modeled involved only a single center pivot or wheel line. The cost of turn outs in a multiple pivot system were added, however. For example, $3,000 of additional costs were included for a multiple system composed of two center pivots, $1,500 for each of two turn outs.

Lateral Electrical Costs: 0

No electrical demand was attributed to the laterals. Thus, no costs were included.

Land Rights: 0

Land right costs are assumed to be zero, since the model identifies small acreages and the time involved in identifying land right problems is prohibitive for this study.

Reach: 1

This reach identifies the basic parameters needed to design the pump system. There are nine parameters that are inclusive to this reach.

Number of Pumps: 1

Average Column Diameter: 8 inch (center pivot), 6 inch (wheel line)

Maximum Lift from Water: 5 feet

Minimum Outlet Pressure: 0

This is the minimum pressure needed at the inlet to the on-farm system. Since the pump is attached to the pipeline, zero pressure is assumed. IRRSYS will determine the minimum outlet pressure needed for the pipeline.

Powerline Length

Because the upper Clark Fork basin is in the Montana Power Company service area, no costs were entered into the model for powerline construction. The Montana Power Company constructs powerlines without directly assessing the user for the cost.

Total Static Head: 0

Static head is zero because of the type of system modeled.

Inlet Operating Pressure: 0

Inlet operating pressure is zero due to the type of system modeled.

Additional Flow: 0

Additional flow is zero because of the type of system modeled.

Reach #2

This reach identifies the basic parameters of the water delivery system from the pump to the on-farm system. The first input identifies the type of delivery system (earth canel or pipeline) and the type of material used (PVC or welded steel pipe (WSP)). There are six parameters that are inclusive of this reach.

Reach Length: (variable)

This variable along with elevation change are key to the estimation of irrigable acres. By incrementally increasing reach length and distance the cost matrices are created. The underlying relationship of increasing system costs associated with increasing distances and lifts from the pump allowed the creation of the cost matrices. Reach length was increased by 1/10th of a mile increments up to 6 miles.

Acres Served: (variable)

Acres served specifies system size. For example, a 135 center pivot serves 135 acres.

Maximum Head Loss: 10 Feet

Maximum head loss represents the amount of pressure needed to compensate for friction loss in the pipeline. The USDA-SCS staff in Bozeman provided this figure as representative of typical pipeline system (10 feet/1,000 feet of pipeline).

Elevation Change: (variable)

As discussed previously, elevation change is a key variable in estimating irrigable acres. Elevation was increased by 20 feet intervals up to 1,200 feet of lift.

Minimum Outlet Pressure

Minimum outlet pressure is the pressure required to pump water through the sprinkler heads of the on-farm system. These pressures were provided by the USDA-SCS staff in Bozeman for typical systems.

Additional Flows: 0

Additional flows are only needed with systems that include laterals. The systems we have modeled do not include any laterals.

Acres Served: Pivot Size

See Maximum Head Loss above.

Maximum Head Loss: 10 Feet

See Elevation Change above.

Elevation Change: 0

A level bench is assumed.

Minimum Outlet Pressure: 30 psi

See Additional Flows above.

Electric Rates: $3.04/KwHr

Current Montana Power Company charge to irrigators.

Electric Growth Rate: .58/year

Based on data presented by the Montana Power Company in the Salem Project Application submitted to the Montana Department of Natural Resources and Conservation.

Number of Electrical Growth Years: 15 Years

Based on data presented by the Montana Power Company in the Salem Project Application submitted to the Montana Department of Natural Resources and Conservation.

IRRSYS INPUT VARIABLES

Name of file: Irrsys.dat(see following pages)

% of Alfalfa: 100%

Peak Use: variable depending on hydrologic region.

Ave. Annual Use: variable depending on hydrologic region.

% Sprinkler Acreage: 100%

Ave. Irrigation Efficiency: 70% (center pivot) or 65% (wheel line)

Max. Net Application: 2 in. (center pivot) or 3 In.(wheel line)

Ave. Pumping Head: variable depending on pivot size.

Peak Management Efficiency: 95%

Seasonal Management Efficiency: 85%

Storage Costs: 0

Additional Costs: 0 for single irrigation system, include turn out costs for multiple irrigation system.

Lateral Electrical Energy: 0

Land Right Costs: 0

Reach: 4

# of Pumps: 1

Ave. Column Diameter: 8 in.(center pivot) or 6 in. (wheel line)

Ave. Column length: 10 ft.

Max. Lift from Water Source: 5 ft.

Min. Outlet Pressure: 0

Powerline Length: 2 mi.

Total Static Head: 0

Inlet Operating Pressure: 0

Additional Flow Required: 0

Reach: variable depending on pipe used- pvc or wsp.

Reach Length: variable.

Acres Served: variable.

Max. Head Loss: 10 ft.

Elevation Change: variable.

Min. Outlet Pressure: 30 psi (center pivot) or 50 psi (wheel line).

Additional Flow: 0

Reach: may be additional reaches if multiple pivots are modeled.

Source: Communication with and review by the U.S. Department of Agriculture: Soil Conservation Service, Bozeman Montana.

Row							
1	B1	B2	Z1	ANO	AN1	V1	AKO
2	T1	T2	Z3	Z4	B3	B4	Z2
3	AN2	V2	AK1	AK2	D3	AK3	AN3
4	AK4	AN4	E8	E9	D5	AK5	AN5
5	V5	T5	AK6	AN6	V6	P6	W6
6	T6	F8	F9				
7	CO	C1	C2	C3	U(1)	U(2)	U(3)
8	U(4)	U(5)	U(6)	U(7)	U(8)	U(9)	U(10)
9	U(11)	U(12)	U(13)	U(14)	E5	E6	C4
10	E7	C5	C6	BO	C7	F4	G4
11	F5	G5	G6	AI1	AI2	YO	Y1
12	Y2	Y3	AI3	AI4	AI5	AI6	Y4
13	Y5						

DESCRIPTION OF VARIABLES USED IN IRRSYS PROGRAM

B1	Earth Canal Minimum Bottom Width (FT)
B2	Earth Canal Maximum Bottom Width (FT)
Z1	Earth Canal Inner Side Slopes Z1:1
ANO	N-Value of Aged Channel
AN1	N-Value of Newly Constructed Channel for TR#25 Stability Check
V1	Maximum Allowable Velocity (FPS) for Stability Check
AKO	Water Surface Evaporation At Peak Delivery (In/Day)

T1	Canal Top Width on Downhill Side (FT)*
T2	Canal Top Width on Uphill Side (FT)*
Z3	Side Slope For Fill Areas Other Than Canal Inner Slopes Z3:1*
Z4	Side Slope For Excavated Areas Other Than Canal Inner Slopes Z4:1*
B3	Concrete Lined Canal Minimum Bottom Width (FT)
B4	Concrete Lined Canal Miximum Bottom Width (FT)
Z2	Concrete Lined Canal Inner Side Slopes Z2:1

AN2	N-Value of Concrete Lined Canal
V2	Concrete Lined Canal Miximum Water Velocity (FPS)
AK1	Ratio of Seepage Cracks to Wetted Area In Lined Canal
AK2	Concrete Canal Lining Thickness (IN)
D3	Siphon Maximum Diameter (IN)
AK3	Siphon Sum of Loss Coefficients
AN3	N-Value for Siphon (Concrete Pipe)

AK4	Pump Sum of Loss Coefficients
AN4	N-Value for Pump Inlet Pipes
E8	Pump Efficiency
E9	Motor Efficiency (Pump Drive)
D5	Welded Steel Pipe Maximum Diameter (IN)
AK5	Welded Steel Pipe Sum of Loss Coefficients
AN5	N-Value Welded Steel Pipe

V5	Welded Steel Pipe Maximum Water Velocity (FPS)
T5	Steel Yield-Point Stress (PSI)
AK6	PVC-IPS & PVC-PIP Sum of Loss Coefficients
AN	PVC-IPS & PVC-PIP Hazen-Williams Design C
V6	PVC-IPS & PVC-PIP Maximum Water Velocity
P6	PVC-IPS & Minimum Pressure Rating (PSI)
W6	Maximum Working Pressure SF (%)
T6	PVC-IPS & PVC-PIP Hydrostatic Design Stress (PSI)
F8	On-Farm Pump Efficiency
F9	On-Farm Motor Efficiency
CO	Unit Cost of Earth Fill ($/CYD)
C1	Unit Cost of Earth Excavation ($/CYD)
C2	Unit Cost of Concrete Lining ($/CYD)
C3	Unit Cost of Structural Concrete ($/CYD
U(1)	Unit Cost 12-Inch RCP Siphon
U(2)	Unit Cost 15-Inch RCP Siphon
U(3)	Unit Cost 18-Inch RCP Siphon
U(4)	Unit Cost 21-Inch RCP Siphon
U(5)	Unit Cost 24-Inch RCP Siphon
U(6)	Unit Cost 27-Inch RCP Siphon
U(7)	Unit Cost 30-Inch RCP Siphon
U(8)	Unit Cost 36-Inch RCP Siphon
U(9)	Unit Cost 42-Inch RCP Siphon
U(10)	Unit Cost 48-Inch RCP Siphon
U(11)	Unit Cost 54-Inch RCP Siphon
U(12)	Unit Cost 60-Inch RCP Siphon
U(13)	Unit Cost 66-Inch RCP Siphon
U(14)	Unit Cost 72-Inch RCP Siphon
E5	Unit Cost of Electricity ($/KW-HR)
E6	Electricity Demand Charge ($/BHP)
C4	Unit Cost of Pumps ($/BHP)
E7	Unit Cost of Power Line Construction ($/Mile)
C5	Unit Cost of Welded Steel Pipe ($/LB)**
C6	Unit Cost of Welded Steel Pipe ($/DIA-IN)**
BO	Unit Cost of Pipe Bedding ($/CYD)
C7	Unit Cost of PVC-IPS & PVC-PIP Pipe ($/LB)***
F4	Sprinkler or Pumping Irrigation System Cost ($/AC)
G4	Flood Irrigation System Cost ($/AC)
F5	Sprinkler Irrigation Labor Requirement (HR/AC/IRR)
G5	Flood Irrigation Labor Requirement (HR/AC/IRR)
G6	Irrigation Labor Cost ($/HR)
AI1	Project Interest Rate (%)

AI2	On-Farm Interest Rate (%)
YO	Construction Period (YRS)
Y1	Expected Project Life (YRS)
Y2	Expected Pump Life (YRS)
Y3	Expected On-Farm System Life (YRS)
AI3	O&M (%) - Pipelines, Structures, Etc.
AI4	O&M - Ditches and Concrete Lining
AI5	O&M - Pumps
AI6	O&M - On-Farm Systems
Y4	Contingency Factor for Planning to Design (%)
Y5	Engineering and Project Administration Costs (%)

*	These values are used for both earth and concrete lined canals.
**	WSP installation cost = (1.6)[(weight of pipe)(C5)+(DIA)(C6)I+Bedding
***	PVC installation cost = (1.6) (weight of pipe)(C7)+Bedding
1.6 *	Unit cost of pipe accounts for trench excavation, shaping, backfill, equipment, and labor based on estimates in dodge guide to construction costs - 1977.

IRRSYS INPUT MATRIX*

```
   1.0        14.0        1.5        0.030     0.025      3.5       0.25
  12.0         4.0        2.0        1.5       1.0        6.0       1.25
   0.015      15.0        0.001      3.0      72.0        1.5       0.011
   1.9         0.012      0.80       0.91     72.0        1.0       0.012
  15.0     33000.0        1.0      150.0       5.1      100.0      72.0
2000.0         0.77       0.89
   1.00        1.50     140.00     550.00     15.80      19.80     25.30
  29.00       33.20      42.30      49.70     71.20      94.20    114.70
 137.00      162.00     192.00     225.40      0.0304    12.54    125.00
   0.00        0.34       0.25       5.00      0.60     350.00    250.00
   0.10**      0.50       4.00       5.000     5.000      1.00     50.0
  20.0        20.0        0.50       1.0       1.5        1.5      10.0
  00.0
```

---

*See Definition of Variables Overleaf

**.1 for center pivots and .2 for wheel lines

APPENDIX B

PRELIMINARY ECONOMIC ANALYSIS BY GRANITE COUNTY CONSERVATION DISTRICT

6-22-84

Evaluation on Feasibility of Dam in Granite County

Two landowners in the project area were interviewed to obtain cost and return information for raising irrigated crops. Information was obtained for tearing out hay or sod, establishing hay, and hay. This enterprise information was used to estimate per acre costs and returns. The AGNET system was used to obtain the results. Copies of the output for the six budgets that were run are attached.

The cost and return information for the two landowners was averaged together to obtain an average cost for each enterprise. Yield information and crop mix was also obtained for with and without project situations. This enabled net returns per acre to be calculated for with and without project situations. The change in net farm income as a result of project action would be $76.43 per acre. If you assume two acre feet of water are required for each irrigated acre the net return per acre foot is $38.21.

1) Cost of delivered water? [illegible] [illegible]
[illegible] in [illegible]

2)

6-22-84

Philipsburg Dam Evaluation

Without project

.25 AUMs × 15.00/AUM =   Typical 8 years
w/ alfalfa
rotation w/
small grain $3.75/acre

with Project - 8 year rotation

Tear out   year one   produce 80 bu grain

(-2.31) net return from one [illegible]
(12.67) " " " 2nd [illegible]
10.36 ÷ 2 = $5.18/ac × .125 (composite acre) $.65/year
average return

Establish hay   divide by 8 (years

-16.24 } year #2
17.07 }
.83 ÷ 2 = $.42/ac × .125 (composite acre) $.05
3 tons/acre

Hay   averaged over 6 years -

111.05 } net return over 6 years
100.89 }
211.94 ÷ 2 = 105.97 × .75 (composite acre) $79.48
future with project returns   80.18

3-8 years
4 tons/acre

Change in net farm income
80.18-3.75= 76.43/acre

Assume 2 acre feet of water needed per acre

Change in net farm income per acre foot =
76.43 ÷ 2 = $38.21/acre feet

494.07

6-22-84

```
                                  DINSMORE
                                   TEAROUT

TOTAL CROPLAND ACRES          250.0          EXPECTED YIELD PER ACRE      80.0
ACRES THIS CROP BUDGET         30.0          ANIMAL UNITS OF GRAZING       0.0


                                           PURCHASED       MACHINERY COSTS
                                           MATERIALS     FUEL  REPAIR
                                  ACRES   AMOUNT  COST    AND    AND              TOTAL
        OPERATION                 /HOUR   /ACRE  /UNIT    LUBE  MAINT.  FIXED     COSTS
---------------------------------------------------------------------------------------
MOLDBOARD PLOW                     2.00                   1.44   2.66    8.84     12.95
TANDEM DISC                        6.50                   0.44   0.97    3.61      5.02
TANDEM DISC                        6.50                   0.44   0.97    3.61      5.02
SPIKE TOOTH HARROW              IN TANDEM                 0.0    0.00    0.32      0.32
GRAIN DRILL                        4.00                   0.79   0.80    3.37      4.97
         SEED                              1.00   6.00                             6.00
         SPRINKLER                         1.00  70.00                            70.00
ROLLER OR PACKER                   7.50                   0.39   0.57    3.39      4.34
SPRAYER                           CUSTOM                                           6.00
COMBINE, JD55                      2.00                   1.58   2.00   11.27     14.85
TRUCK                                                     1.20   0.24    0.96      2.40
---------------------------------------------------------------------------------------
TOTALS                                                    6.29   8.20   35.38    131.87

CASH COSTS
         PURCHASED MATERIALS                                   76.00
         FUEL AND LUBE                                          6.29
         REPAIRS AND MAINTANANCE                                8.20
         CUSTOM HIRE AND MACHINE RENTAL                         6.00
         INTEREST ON OPERATING EXPENSE                          7.72
              ( 96.49 X 16.00% FOR  6.0 MONTHS)
                   TOTAL CASH COSTS                                            104.21

LABOR
         DIRECT LABOR                                           8.12
              ( 1.7 HRS X  4.00/HR X 1.2 (OVERHEAD))
                   TOTAL CASH COSTS AND LABOR                                  112.33

FIXED COSTS
         FIXED MACHINERY COSTS (INCLUDES INTEREST AT 16.00%)   35.38
         REAL ESTATE TAXES                                      3.00
         INTEREST ON LAND ($   0.0  VALUE/A X  0.0 % X 1.0)     0.0
                   TOTAL FIXED COSTS                                            38.38
                   TOTAL COST, EXCEPT OVERHEAD AND MGT.                        150.70
                                                                                80.7
OVERHEAD AND MANAGEMENT
         OVERHEAD  (TOTAL CASH COSTS X  5.00%)                  5.21
         MANAGEMENT CHARGE  ($ 0.0  X ESTIMATED YIELD)          0.0
                   TOTAL OVERHEAD AND MANAGEMENT                                 5.21
                   TOTAL COST PER ACRE                                         155.91
                   TOTAL COST PER UNIT OF PRODUCTION                             1.95
                      (BASED ON ESTIMATED YIELD)                          $85.91

ESTIMATED RETURNS
         ESTIMATED CROP RETURN PER ACRE                       153.60
         ESTIMATED AUM GRAZING RETURNS                          0.0
                   ESTIMATED TOTAL RETURN PER ACRE                             153.60
              ESTIMATED NET RETURN PER ACRE              -2.31
---------------------------------------------------------------------------------------

DO YOU WANT TO RUN, LIST, CHANGE, ADD, DELETE OR STOP?
```

```
                                        HAY

TOTAL CROPLAND ACRES        325.0          EXPECTED YIELD PER ACRE      4.0
ACRES THIS CROP BUDGET      245.0          ANIMAL UNITS OF GRAZING      1.0


                                          PURCHASED       MACHINERY COSTS
                                          MATERIALS      FUEL   REPAIR
                                  ACRES  AMOUNT   COST   AND     AND              TOTAL
       OPERATION                 /HOUR  /ACRE    /UNIT  LUBE   MAINT.  FIXED    COSTS
--------------------------------------------------------------------------------------
SELF-PROPELLED WINDROWER          3.00                  0.84    0.55    2.10     3.49
SELF-PROPELLED BALER              2.60                  0.97    0.37    2.10     3.44
       TWINE                             1.00    2.40                            2.40
SELF-PROP. FORAGE CHOPPER         2.00                  1.26    0.78    2.94     4.98
SELF-PROPELLED WINDROWER          3.00                  0.84    0.55    2.10     3.49
SELF-PROPELLED BALER              2.60                  0.97    0.37    2.10     3.44
       TWINE                             1.00    0.80                            0.80
       SPRINKLER                         1.00   70.00                           70.00
       GOPHER CONTROL                    1.00    1.00                            1.00
SELF-PROP. FORAGE CHOPPER         2.00                  1.26    0.78    2.94     4.98
--------------------------------------------------------------------------------------
TOTALS                                                  6.16    3.40   14.26    98.03

CASH COSTS
        PURCHASED MATERIALS                                     74.20
        FUEL AND LUBE                                            6.16
        REPAIRS AND MAINTANANCE                                  3.40
        CUSTOM HIRE AND MACHINE RENTAL                           0.0
        INTEREST ON OPERATING EXPENSE                            6.70
             (  83.76 X 16.00% FOR  6.0 MONTHS)
                  TOTAL CASH COSTS                                        90.47

LABOR
        DIRECT LABOR                                            11.69
             (  2.4 HRS X  4.00/HR X 1.2 (OVERHEAD))
                  TOTAL CASH COSTS AND LABOR                             102.16

FIXED COSTS
        FIXED MACHINERY COSTS (INCLUDES INTEREST AT 16.00%)     14.26
        REAL ESTATE TAXES                                        3.00
        INTEREST ON LAND ($    0.0  VALUE/A X   0.0 % X 1.0)     0.0
                  TOTAL FIXED COSTS                                       17.26
                  TOTAL COST, EXCEPT OVERHEAD AND MGT.                   119.42

OVERHEAD AND MANAGEMENT
        OVERHEAD  (TOTAL CASH COSTS X   5.00%)                   4.52
        MANAGEMENT CHARGE  ($ 0.0   X ESTIMATED YIELD)           0.0
                  TOTAL OVERHEAD AND MANAGEMENT                            4.52
                  TOTAL COST PER ACRE                                    123.95
                  TOTAL COST PER UNIT OF PRODUCTION                    /  30.99
                       (BASED ON ESTIMATED YIELD)                      63.95

ESTIMATED RETURNS
        ESTIMATED CROP RETURN PER ACRE                         220.00
        ESTIMATED AUM GRAZING RETURNS                           15.00
                  ESTIMATED TOTAL RETURN PER ACRE                        235.00
             ESTIMATED NET RETURN PER ACRE              111.05
-------------------------------------------------------------------------------------

DO YOU WANT TO RUN, LIST, CHANGE, ADD, DELETE OR STOP?
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                                   DINSMORE
                                     HAY

TOTAL CROPLAND ACRES        250.0          EXPECTED YIELD PER ACRE        4.0
ACRES THIS CROP BUDGET      190.0          ANIMAL UNITS OF GRAZING        1.0


                                          PURCHASED        MACHINERY COSTS
                                          MATERIALS     FUEL   REPAIR
                                  ACRES  AMOUNT  COST   AND     AND             TOTAL
         OPERATION               /HOUR  /ACRE   /UNIT  LUBE   MAINT.  FIXED    COSTS
---------------------------------------------------------------------------------------
SELF-PROPELLED WINDROWER          3.00                  0.84   1.10    4.17     6.11
BALER,REGULAR                     2.60                  1.22   0.68    2.74     4.64
        TWINE                            1.00    2.40                           2.40
SELF-PROP. FORAGE CHOPPER         2.00                  1.26   1.01    3.80     6.07
SELF-PROPELLED WINDROWER          3.00                  0.84   1.10    4.17     6.11
BALER,REGULAR                     2.60                  1.22   0.68    2.74     4.64
        TWINE                            1.00    0.80                           0.80
        SPRINKLER                        1.00   70.00                          70.00
        GOPHER CONTROL                   1.00    1.00                           1.00
SELF-PROP. FORAGE CHOPPER         2.00                  1.26   1.01    3.80     6.07
---------------------------------------------------------------------------------------
TOTALS                                                  6.65   5.58   21.41   107.84

CASH COSTS
         PURCHASED MATERIALS                                          74.20
         FUEL AND LUBE                                                 6.65
         REPAIRS AND MAINTANANCE                                       5.58
         CUSTOM HIRE AND MACHINE RENTAL                                0.0
         INTEREST ON OPERATING EXPENSE                                 6.91
              ( 86.43 X 16.00% FOR  6.0 MONTHS)
                   TOTAL CASH COSTS                                             93.34

LABOR
         DIRECT LABOR                                                 11.69
              ( 2.4 HRS X  4.00/HR X 1.2 (OVERHEAD))
                   TOTAL CASH COSTS AND LABOR                                  105.04

FIXED COSTS
         FIXED MACHINERY COSTS (INCLUDES INTEREST AT 16.00%)          21.41
         REAL ESTATE TAXES                                             3.00
         INTEREST ON LAND ($    0.0  VALUE/A X   0.0 % X 1.0)          0.0
                   TOTAL FIXED COSTS                                            24.41
                   TOTAL COST, EXCEPT OVERHEAD AND MGT.                        129.45

OVERHEAD AND MANAGEMENT
         OVERHEAD   (TOTAL CASH COSTS X  5.00%)                        4.67
         MANAGEMENT CHARGE  ($ 0.0  X ESTIMATED YIELD)                 0.0
                   TOTAL OVERHEAD AND MANAGEMENT                                 4.67
                   TOTAL COST PER ACRE                                         134.11
                   TOTAL COST PER UNIT OF PRODUCTION                            33.53
                         (BASED ON ESTIMATED YIELD)              134.11 - 70 = 64.11

ESTIMATED RETURNS
         ESTIMATED CROP RETURN PER ACRE                              220.00
         ESTIMATED AUM GRAZING RETURNS                                15.00
                   ESTIMATED TOTAL RETURN PER ACRE                             235.00
              ESTIMATED NET RETURN PER ACRE                    100.89
---------------------------------------------------------------------------------------

DO YOU WANT TO RUN, LIST, CHANGE, ADD, DELETE OR STOP?
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                                   DINSMORE
                                   ESTAB HAY

TAL CROPLAND ACRES        250.0         EXPECTED YIELD PER ACRE       3.0
RES THIS CROP BUDGET       30.0         ANIMAL UNITS OF GRAZING       1.0


                                         PURCHASED       MACHINERY COSTS
                                         MATERIALS     FUEL   REPAIR
                               ACRES   AMOUNT   COST   AND     AND             TOTAL
       OPERATION               /HOUR   /ACRE   /UNIT   LUBE   MAINT.  FIXED    COSTS
-----------------------------------------------------------------------------------
OLDBOARD PLOW                  2.00                    1.44    2.66    8.84    12.95
ANDEM DISC                     6.50                    0.44    0.97    3.61     5.02
PIKE TOOTH HARROW            IN TANDEM                 0.0     0.00    0.32     0.32
LOAT                           1.50                    2.11    1.32    5.73     9.16
LOAT                           1.50                    2.11    1.32    5.73     9.16
RAIN DRILL                     4.00                    0.79    0.80    3.37     4.97
       SEED                             1.00   25.00                           25.00
       SPRINKLER                        1.00   70.00                           70.00
OLLER OR PACKER                7.50                    0.39    0.57    3.39     4.34
ELF-PROPELLED WINDROWER        3.00                    0.84    1.10    4.17     6.11
ALER,REGULAR                   2.60                    1.22    0.68    2.74     4.64
        TWINE                           1.00    2.40                            2.40
ELF-PROP. FORAGE CHOPPER       2.00                    1.26    1.01    3.80     6.07
-----------------------------------------------------------------------------------
OTALS                                                 10.60   10.44   41.70   160.15

ASH COSTS
        PURCHASED MATERIALS                                       97.40
        FUEL AND LUBE                                             10.60
        REPAIRS AND MAINTANANCE                                   10.44
        CUSTOM HIRE AND MACHINE RENTAL                             0.0
        INTEREST ON OPERATING EXPENSE                              9.48
             ( 118.44 X 16.00% FOR  6.0 MONTHS)
                  TOTAL CASH COSTS                                          127.92

LABOR
        DIRECT LABOR                                              17.22
             (  3.6 HRS X  4.00/HR X 1.2 (OVERHEAD))
                  TOTAL CASH COSTS AND LABOR                                145.14

FIXED COSTS
        FIXED MACHINERY COSTS (INCLUDES INTEREST AT 16.00%)       41.70
        REAL ESTATE TAXES                                          3.00
        INTEREST ON LAND ($    0.0  VALUE/A X   0.0 % X 1.0)       0.0
                  TOTAL FIXED COSTS                                          44.70
                  TOTAL COST, EXCEPT OVERHEAD AND MGT.                      189.85

OVERHEAD AND MANAGEMENT
        OVERHEAD  (TOTAL CASH COSTS X  5.00%)                      6.40
        MANAGEMENT CHARGE  ($ 0.0  X ESTIMATED YIELD)              0.0
                  TOTAL OVERHEAD AND MANAGEMENT                               6.40
                  TOTAL COST PER ACRE                                       196.24
                  TOTAL COST PER UNIT OF PRODUCTION                          65.41
                       (BASED ON ESTIMATED YIELD)                           126.24

ESTIMATED RETURNS
        ESTIMATED CROP RETURN PER ACRE                           165.00
        ESTIMATED AUM GRAZING RETURNS                             15.00
                  ESTIMATED TOTAL RETURN PER ACRE                           180.00
             ESTIMATED NET RETURN PER ACRE               -16.24
-----------------------------------------------------------------------------------
```

GARY METZER
ESTAB HAY

```
TOTAL CROPLAND ACRES        325.0       EXPECTED YIELD PER ACRE      3.0
ACRES THIS CROP BUDGET       40.0       ANIMAL UNITS OF GRAZING      1.0


                                        PURCHASED      MACHINERY COSTS
                                        MATERIALS     FUEL   REPAIR
                               ACRES   AMOUNT   COST    AND     AND              TOTAL
         OPERATION             /HOUR   /ACRE   /UNIT   LUBE   MAINT.  FIXED     COSTS
-----------------------------------------------------------------------------------
MOLDBOARD PLOW                  2.50                   0.69    1.05    2.90      4.65
TANDEM DISC                     4.00                   0.43    0.31    1.19      1.93
SPIKE TOOTH HARROW           IN TANDEM                 0.0     0.00    0.24      0.25
FLOAT                           2.00                   0.87    0.52    2.36      3.75
FLOAT                           2.00                   0.87    0.52    2.36      3.75
ROLLER OR PACKER                7.50                   0.23    0.08    0.96      1.27
GRAIN DRILL                     4.00                   0.43    0.46    2.03      2.98
        SEED                            1.00   25.00                            25.00
                                        0.01    0.01                             0.00
        SPRINKLER                       1.00   70.00                            70.00
ROLLER OR PACKER                7.50                   0.23    0.08    0.96      1.27
SELF-PROPELLED WINDROWER        3.00                   0.84    0.55    2.10      3.49
SELF-PROPELLED BALER            2.60                   0.97    0.37    2.10      3.44
        TWINE                           1.00    2.40                             2.40
SELF-PROP. FORAGE CHOPPER       2.00                   1.26    0.78    2.94      4.98
-----------------------------------------------------------------------------------
TOTALS                                                 6.84    4.71   20.14    129.09

CASH COSTS
         PURCHASED MATERIALS                                    97.40 - 70 = 27.40
         FUEL AND LUBE                                           6.84
         REPAIRS AND MAINTANANCE                                 4.71
         CUSTOM HIRE AND MACHINE RENTAL                          0.0
         INTEREST ON OPERATING EXPENSE                           8.72
              ( 108.95 X 16.00% FOR  6.0 MONTHS)
                   TOTAL CASH COSTS                                          117.67
                                                                              45.67
LABOR
         DIRECT LABOR                                           16.25
              (  3.4 HRS X  4.00/HR X 1.2 (OVERHEAD))
                   TOTAL CASH COSTS AND LABOR                                133.91

FIXED COSTS
         FIXED MACHINERY COSTS (INCLUDES INTEREST AT 16.00%)    20.14
         REAL ESTATE TAXES                                       3.00
         INTEREST ON LAND ($    0.0  VALUE/A X   0.0 % X 1.0)    0.0
                   TOTAL FIXED COSTS                                          23.14
                   TOTAL COST, EXCEPT OVERHEAD AND MGT.                      157.05

OVERHEAD AND MANAGEMENT
         OVERHEAD  (TOTAL CASH COSTS X  5.00%)                   5.88
         MANAGEMENT CHARGE  ($ 0.0  X ESTIMATED YIELD)           0.0
                   TOTAL OVERHEAD AND MANAGEMENT                               5.88
                   TOTAL COST PER ACRE                                       162.93
                   TOTAL COST PER UNIT OF PRODUCTION                          54.31
                        (BASED ON ESTIMATED YIELD)                        92.43

ESTIMATED RETURNS
         ESTIMATED CROP RETURN PER ACRE                        165.00
         ESTIMATED AUM GRAZING RETURNS                          15.00
```

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                                          GARY METZER
                                          BREAKING SOD                              6-22-84

TOTAL CROPLAND ACRES          325.0        EXPECTED YIELD PER ACRE      80.0
ACRES THIS CROP BUDGET         40.0        ANIMAL UNITS OF GRAZING       0.0


                                           PURCHASED      MACHINERY COSTS
                                           MATERIALS    FUEL   REPAIR
                                  ACRES   AMOUNT   COST   AND     AND              TOTAL
         OPERATION                /HOUR   /ACRE   /UNIT  LUBE   MAINT.  FIXED     COSTS
-----------------------------------------------------------------------------------------
MOLDBOARD PLOW                     2.50                  0.69    1.05    2.90      4.65
TANDEM DISC                        4.00                  0.43    0.31    1.19      1.93
TANDEM DISC                        4.00                  0.43    0.31    1.19      1.93
SPIKE TOOTH HARROW                10.00                  0.17    0.04    0.37      0.58
FLOAT                              2.00                  0.87    0.52    2.36      3.75
GRAIN DRILL                        4.00                  0.43    0.46    2.03      2.92
        SEED                               1.00    6.00                            6.00
        GOPHER CONTROL                     1.00    1.00                            1.00
        SPRINKLER                          1.00   70.00                           70.00
ROLLER OR PACKER                   7.50                  0.23    0.08    0.96      1.2
SPRAYER                           CUSTOM                                           6.00
COMBINE, 55JD                      2.00                  1.58    1.50    8.45     11.53
TRUCK                                                    1.20    0.24    0.96      2.4
-----------------------------------------------------------------------------------------
TOTALS                                                   6.04    4.50   20.41    113.95

CASH COSTS
         PURCHASED MATERIALS                                         77.00
         FUEL AND LUBE                                                6.04
         REPAIRS AND MAINTANANCE                                      4.50
         CUSTOM HIRE AND MACHINE RENTAL                               6.00
         INTEREST ON OPERATING EXPENSE                                7.48
              (  93.54 X 16.00% FOR  6.0 MONTHS)
                   TOTAL CASH COSTS                                             101.03

LABOR
         DIRECT LABOR                                                11.44
              (  2.4 HRS X  4.00/HR X 1.2 (OVERHEAD))
                   TOTAL CASH COSTS AND LABOR                                   112.47

FIXED COSTS
         FIXED MACHINERY COSTS (INCLUDES INTEREST AT 16.00%)         20.41
         REAL ESTATE TAXES                                            3.00
         INTEREST ON LAND ($    0.0  VALUE/A X  0.0 % X 1.0)          0.0
                   TOTAL FIXED COSTS                                             23.41
                   TOTAL COST, EXCEPT OVERHEAD AND MGT.                         135.88
                                                                                 65.88
OVERHEAD AND MANAGEMENT
         OVERHEAD  (TOTAL CASH COSTS X  5.00%)                        5.05
         MANAGEMENT CHARGE  ($ 0.0  X ESTIMATED YIELD)                0.0
                   TOTAL OVERHEAD AND MANAGEMENT                                  5.05
                   TOTAL COST PER ACRE                                          140.93
                   TOTAL COST PER UNIT OF PRODUCTION                              1.76
                        (BASED ON ESTIMATED YIELD)                       70.43

ESTIMATED RETURNS
         ESTIMATED CROP RETURN PER ACRE                             153.60
         ESTIMATED AUM GRAZING RETURNS                                0.0
                   ESTIMATED TOTAL RETURN PER ACRE                              153.60
              ESTIMATED NET RETURN PER ACRE                  12.67
-----------------------------------------------------------------------------------------
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APPENDIX C

HEAVY METAL PROBLEMS IN THE DEER LODGE VALLEY

APPENDIX C

HEAVY METALS

Contamination of soils by heavy metals in the upper Clark Fork drainage is a problem which limits the production potential of some lands and may seriously impair water quality. Airborne heavy metal particulates have been emitted from the Anaconda Smelter since the late 1800s and have settled on land in the Deer Lodge Valley. Additional waterborne mine tailings with high heavy metal concentrations have contaminated floodplain soils and some agricultural land in close proximity to the Clark Fork River.

Heavy metals in soils impose constraints on various land uses including irrigated agriculture. The following studies have addressed the heavy metal problems in the Deer Lodge Valley or in the riverine ecosystem downstream.

A. MultiTech

The consulting firms of MultiTech and Stiller and Associates have contracted with the Montana Department of Health and Environmental Sciences (DHES) through the federally funded Superfund Program to prepare the Silver Bow Creek Remedial Investigation Work Plan. This plan describes the many problems in the Anaconda-Butte area associated with past mining and smelting activities and suggests means to reduce or better identify the problems.

MultiTech cites the work of various agencies and consultants and states:

> Just downstream of the Warm Springs Ponds, Warm Springs Creek and Silver Bow Creek converge to form the Clark Fork River. Warm Springs Creek is a high quality stream that is degraded in its lower reaches. The cause of the degradation is possibly a combination of seepage from AMC treatment ponds and irrigation dewatering (Casne and others 1975). Tailings deposits cover much of the floodplain of the Upper Clark Fork and contribute unknown contaminants, via runoff, to the river. MDHES (1983) study found an increase in sulfate and total copper loads for the Clark Fork River from its origin to Deer Lodge. This increase is thought to be the result of impacts from floodplain and in-stream tailing deposits (Green 1984).
>
> Tributaries to the Clark Fork River along this reach are affected by some mining and agricultural activity. These lands may produce some contaminant loads to the Clark Fork River.

MultiTech additionally states,

> Soil contamination along the Upper Clark Fork River is nearly identical to that described for the canyon to Warm Springs Ponds river segments. A much greater extent of irrigated land is found along this portion of the Clark Fork. The downstream extent of significant contamination is presently indeterminate. Barren areas are common aong the river point bars as far as Deer Lodge. It is expected that contamination could occur at least as far downstream as Garrison.
>
> The literature review in Section 9.4.2 documents the need for systematic identification and demarcation of those lands either known or suspected to be affected by "heavy metal" contaminated irrigation waters. Initially, those ditches that received surface waters diverted or pumped from either Silver Bow Creek or Upper Clark Fork River were identified. This effort was accomplished via review of the respective water resource surveys for Silver Bow (Buck _et al_. 1955a), Deer Lodge (Buck _et al_. 1955b), and Powell Counties (Buck _et al_. 1959). Secondly, those owners potentially affected were identified either through inspection of each county's land ownership (plat) books or interviewing knowledgeable Soil Conservation Service personnel in Deer Lodge (Tribelhorn and Dutton, personal communications). Thirdly, a news release was published on February 28, 1984 in the _Montana Standard_ (Kemmick

1984) that included a solicitation for information pertinent to the irrigated lands study. The initial listing of persons that will be contacted are presented by soil conservation district in Appendix Table 9.5-5.

A preliminary estimate of areal extent of affected lands totals to 5380 acres, for the three given counties. The respective county figures are as follows: Silver Bow, 0 acres; Deer Lodge, 1115 acres; and Powell, 4265 acres. Apparently, the combined municipal and industrial effluents discharged by Butte sources into Silver Bow Creek have prevented any attempts at using its water for regular or flood irrigation purposes (Buck *et al*. 1955a). The inclusion of the entire Deer Lodge Valley Conservation District seems appropriate, as waters from the Clark Fork River are pumped or diverted from it throughout this area. Furthermore, "heavy metal" contamination of riparian vegetation by sediments has been documented in the vicinity of Drummond, Montana (Ray 1983). This town is located approximately 10 river miles west of the Granite County-Powell County border, implying that transport of effluents has traveled (historically) at least this far downstream.

B. University of Montana

The Gordon Environmental Studies Laboratory of the University of Montana has recently completed studies on the Grant-Kohrs Ranch, a National Historic Site administered by the National Park Service, and on the floodplain of the Clark Fork River between Rocker and Drummond. These studies were conducted to measure heavy metal contamination in soils which are barren of vegetation or have plant communities indicative of heavy metal pollution.

Ray (1984) found elevated levels of copper, cadmium, and arsenic at all sites studied along the Clark Fork with some of the highest concentrations being present at Drummond, the site farthest from the source of the waterborne mine tailings. All of Ray's samples were collected on barren or sparsely vegetated areas which showed surficial evidence of waterborne sediment deposition.

Rice and Ray (1984) conducted a floral and faunal survey of the Grant-Kohrs Ranch National Historic Site. They found that the top 25 centimeters of soil on the Clark Fork floodplain had metal concentrations one to two orders of magnitude greater than the concentrations in the control samples. Only a small fraction of this contamination was attributed to deposition of airborne particulates during the period of smelter operation, 1884 through 1980. Deposition on the floodplain of toxic metal enriched sediments was determined by Rice and Ray to be the predominant and continuing mechanism of contamination.

C. Hydrometrics

The consulting firm, Hydrometrics (1983), conducted long-term environmental rehabilitation studies in the Deer Lodge Valley under contract to the Anaconda Minerals Company. Hydrometrics reported that milling and smelting operations at Butte and Anaconda have resulted in extensive but relatively thin tailings deposits on the floodplain. These deposits have killed riparian vegetation in numerous areas and have created barren or sparsely vegetated areas which resulted from past attempts to irrigate with poor quality water diverted from the Clark Fork River. Field reconnaissance and aerial photo-interpretation were used to map approximately one million cubic yards of tailings (covering 1,250 acres) deposited on the floodplain between Warm Springs and Deer Lodge.

Hydrometrics also conducted soil tests in the Deer Lodge Valley. They found that soils with low pHs had sparse vegetation cover and that soil pH was inversely related to soluble metal concentrations. Downward percolation of metals from tailings and redeposition in the underlying alluvial soils has increased concentrations of copper, zinc, manganese, and sulfur to a depth of 24 inches in some sites.

D. Soil Conservation Service

The Soil Conservation Service (SCS) in Deer Lodge has mapped some areas within the Deer Lodge Valley where toxic metals have affected plant growth and soil productivity. The SCS uses the term "slickens" to describe

> An undifferentiated soil type consisting of accumulation of fine-textured materials, such as are separated in placer-mine and ore-mill operations. Slickens from ore mills consist largely of freshly ground rock that commonly have undergone chemical treatment during milling or smelting processes.

SCS personnel are also aware of landowners who have problem soils or suspect that heavy metals have affected their agricultural operations.

E. Graduate Studies

Graduate students at the University of Montana conducted studies on vegetation and soils in the vicinity of Anaconda. Munshower (1972) studied cadmium compartmentation and cycling in grasses and soils of the Deer Lodge Valley and was able to construct isopols which linked areas of similar soil concentrations of cadmium. The isopol concentrations were attributed only to airborne deposition of particulates produced by the smelting of ore.

Other studies were conducted by Taskey (1970) and Hartman (1976). Taskey studied the contamination of soils around Anaconda by airborne heavy metals, whereas Hartman studied the influence of heavy metals on the fungal flora of the soil.

F. Mile High Conservation District

A reclamation project funded by the Montana Department of Natural Resources and Conservation (DNRC) Water Development Bureau has been initiated for the Mile High Conservation District, Deer Lodge Valley Conservation District, and the Headwaters Resource Conservation and Development Area. This research concerns reclamation techniques for heavy metal contaminated agricultural lands in Deer Lodge, Powell, and Silver Bow counties, with the primary focus of the research being on the development of cost-effective practices for reestablishing hay and forage production on soils contaminated by heavy metals. Such reclamation practices, however, must be permanent so future sulfide oxidation does not lower soil pH. In addition, acceptable reclamation practices must not increase the metal content of forage to levels toxic to livestock.

In recognition that irrigated agrculture could affect the vertical and areal distribution of heavy metals in soils and mobilize these metals so as to contaminate surface and shallow ground water, a detailed hydrological investigation will also be part of the reclamation study being conducted by the Mile High Conservation District. Wells, shallow ground water, and surface waters will be monitored to determine how agricultural practices affect the soil/heavy metal/hydrological interactions.

ADDENDUM C

A Literature Evaluation of Montana's Wetted Perimeter Inflection Point Method for Deriving Instream Flow Recommendations

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December, 1986

TABLE OF CONTENTS

Page

INTRODUCTION 1

HISTORY 2

RELATIONSHIPS BETWEEN STREAMFLOW AND FISH POPULATIONS 6

SURVEY AND ANALYSIS OF INSTREAM FLOW METHODS 17

- Survey of Available Techniques 17
  - Non-Field Methods 17
  - Habitat Retention Methods 18
  - Incremental Methods 20
- Advantages and Limitations of IFM's 25
  - Hydraulics and Channel Morphology 26
  - Decision-Making Capabilities 29
  - Data and Manpower Requirements 32
- IFM Evaluation Studies 35
  - Carrying Capacity and Limiting Factors 36
  - Experimental Design 37
  - Evaluations of Montana's Wetted Perimeter Method 41
- Criteria for Selecting an IFM 43

MONTANA'S INSTREAM FLOW METHOD 46

- Wetted Perimeter Inflection Point Method 48
- Brief Description of the Wetted Perimeter (WETP) Computer Program and Data Needs 56

MONTANA'S WETTED PERIMETER METHOD - FINAL CONSIDERATIONS 58

LITERATURE CITED 62

INTRODUCTION

Since the inception of the Montana Department of Fish, Wildlife and Parks' (MDFWP's) instream flow program in the mid-1970's, the wetted perimeter inflection point method has been the primary means for deriving instream flow recommendations for the preservation of aquatic resources during the low-water period in Montana's streams and rivers. Because the field of instream flow method (IFM) development has continually expanded over the past decade or so, the Department felt a need to review its method in light of recent advances in the "state-of-the-art." The purpose of this document is to provide an up-to-date synopsis of the history of the wetted perimeter inflection point method, examine its theoretical and experimental basis, and identify its strengths and weaknesses as compared to other available procedures. We will also discuss the applicability of the wetted perimeter inflection point method to specific lotic habitat types, guidelines for its use, and provide a justification for the use of the method in Montana.

HISTORY

The development of methods to determine the amounts of water to remain instream for the protection of fish and wildlife resources and related recreational opportunities has been a relatively recent phenomenon (Loar and Sale 1981). The primary reason for this has been a reluctance of various state governments to recognize instream uses as "beneficial" uses of water. Because of limited water availability and resultant user conflicts, it was in the arid western states where instream flow methods (IFM's) were first devised. These developments followed the establishment of institutional frameworks (instream flow programs) which have proliferated in the western states since 1973 (Lamb and Meshorer 1983). However, the degree of protection afforded to fish and wildlife by instream flow programs differs markedly among states due to differing levels of statutory protection, water availability, and user conflicts. Consequently, a variety of IFM's have been devised by state fisheries agencies to meet the needs of their particular instream flow programs (Trihey and Stalnaker 1985). Another factor contributing to the diversification of IFM's was that the characteristics of aquatic resources (such as warmwater vs. coldwater habitat, anadromous vs. resident salmonids) vary both within and between states.

Many of the first studies concerning instream flow needs were conducted during the 1950's and 1960's below federally funded hydroelectric and irrigation dams on large rivers in the Far West (Trihey and Stalnaker 1985). Because these projects had their greatest potential impacts on traditionally low summer streamflows, biologists were most concerned with setting minimum flow "standards" for the low flow periods. The first applications of IFM's to streams and rivers on a statewide basis began in Oregon during the late 1960's. The early development of IFM's in Oregon was not just coincidence because in 1955 Oregon became the first western state to provide for the administrative establishment of flow standards. Their program was quite successful and has been a prototype for other western states, including Montana (Lamb and Meshorer 1983).

A series of workshops were held in the Northwest during the early 1970's to review and discuss recent IFM advances. However, three of the most significant events in the development of IFM's did not occur until 1976. The first event was a publication by Stalnaker and Arnette (1976) that comprised the first compilation and critical evaluation of existing IFM's. Second, a conference sponsored by the Western Division of the American Fisheries Society was held in Boise, Idaho. This landmark event brought together IFM practitioners, developers and administrators to discuss the legal, social and biological aspects of the instream flow issue, and resulted in the publication of a two-volume document (Orsborn and Allman 1976). The third significant event was the formation of the Cooperative Instream Flow Service Group (CIFSG) by the U.S. Fish and Wildlife Service at Fort Collins, Colorado. The purpose of this group was to advance the "state-of-the-art" and become the center of activity related to instream flow assessments. In the late 1970's the CIFSG developed the Instream Flow Incremental Method (IFIM) which has been in a continual state of refinement ever since.

The timetable for the development of Montana's IFM closely paralleled those for the other western states. In the early 1960's a series of unsuccessful legislative attempts were made to obtain "beneficial use" status for fish and wildlife and to develop a procedure to obtain instream flows for these resources (Peterman 1979). The first provisions for the instream flow needs for fish and wildlife were made in 1969 when the Montana legislature authorized the Fish and Game Commission to file for rights to the unappropriated waters in portions of 12 streams. Because the "state-of-the-art" of IFM development was in its infancy, most of these original filings were based on the professional judgment of local fisheries biologists. In 1980 and 1981 they were quantified using the wetted perimeter method.

The passage of the Montana Water Use Act in 1973 and the Yellowstone Moratorium in 1974 provided the main stimuli for the development of methods to quantify the instream flow needs of fish and wildlife in Montana. The Water Use Act was a revolutionary legislative act that specifically defined fish and wildlife as beneficial users of water and established a process for reserving unappropriated water for these purposes. The Yellowstone Moratorium was enacted in response to a "rush" of applications for Yellowstone River water by industrial and water-marketing concerns and placed a moratorium on all large diversion or storage applications in the Yellowstone Basin. The Yellowstone Moratorium provided a period of three years to quantify all future beneficial uses (including fish and wildlife) in the basin and allocate water to meet those needs (Peterman 1979).

In 1973 and 1974, in response to this mandate, the MDFWP began in earnest to develop an IFM that was appropriate for the rivers and streams of Montana and could be cost and time-effectively applied on a basinwide scale (Spence 1976). After a review of available IFM's, the MDFWP decided to enter into a cooperative program with the U.S. Bureau of Reclamation and in 1974 began using the Bureau's WSP (water surface profile) model to generate hydraulic and channel configuration information on which instream flow recommendations were based (Spence 1975; Dooley 1976). Data from the WSP model were used to define

(1) passage flows for migratory fish, (2) nest protection flows for Canada geese, and for the first time in Montana, (3) to define minimum flows for fish during the low flow periods based on the relationship between wetted perimeter and discharge in riffles (Elser 1976). Preliminary field testing of the WSP model was conducted during the mid-1970's by MDFWP personnel (Elser 1976; Workman 1976). These evaluations were geared towards the technical aspects of the WSP hydraulic model as well as the appropriateness of using wetted perimeter-discharge relationships to derive instream flow recommendations for the low flow period.

Following the completion of fieldwork associated with the Yellowstone water reservation in 1977, the MDFWP shifted emphasis to the Upper Clark Fork and Upper Missouri River Basins. An action plan was devised to guide Department efforts at securing instream flows (Nelson and Peterman 1979). The wetted perimeter method using the WSP hydraulic model continued to be the primary means of deriving minimum flow recommendations for the low flow period until the results of an evaluation study were published by MDFWP (Nelson 1980a, 1980b and 1980c). This study, funded by the U.S. Fish and Wildlife Service under the auspices of the CIFSG, evaluated four IFM's applied to five river reaches in southwest Montana. Besides providing a basis for using the wetted perimeter inflection point method, the study led to the development of an improved and simplified method to generate wetted perimeter- discharge relationships for streams and rivers (Nelson 1984a). The resultant WETP computer program replaced the WSP model and since 1980 has provided the wetted perimeter-discharge data upon which the Department's flow recommendations are based.

RELATIONSHIPS BETWEEN STREAMFLOWS AND FISH POPULATIONS

Many physical and biological factors interact to regulate fish abundance in streams. Hall and Knight (1981) list five major factors: streamflow, habitat quality, food abundance, predation, and movement and migration. In a natural stream environment, it is difficult to measure the effect of one factor independently of the others. The exact role each factor plays in regulating a given stream population is often masked by the interaction of the others. This complexity hampers the ability of fishery scientists to predict the response of a fish population in a given stream to environmental variations, such as man-caused changes in streamflow. Accurate predictions require the development of a model that quantitatively describes the relationship between fish abundance and all regulating variables. The "state-of-the-art" has not yet advanced to this level, nor is it evident that such models, if ever developed, would be applicable to a broad range of streams.

Because there are wide gaps in our knowledge of how fish respond to environmental changes, fishery scientists must rely on broad, general assumptions when discussing the means by which stream fish populations are regulated. These assumptions may not fully describe the means of regulation for a given stream of interest or apply to all streams in a particular region, and many have not been tested in definitive scientific studies. Despite these limitations, the assumptions, in general, are logical and defensible, but not immune to criticism. These assumptions are an essential part of all instream flow methods. This section will briefly discuss some of the assumptions regarding the regulation of fish abundance in Montana's streams, and provide a basis of support from the scientific literature.

The standing crops (number and total weight) of fish that a particular stream supports can vary over time. For Montana's streams, standing crops are typically lowest following winter and highest in fall after the summer growing season. The magnitude of these annual lows and highs can vary substantially from year-to-year.

A factor often considered a major, if not the overriding, cause of this variability within a particular stream is the year-to-year variation in streamflows. Simply stated, more water translates into more space for fish and the population increases to fill this void. Conversely, lower flows provide less space and lead to a reduction in fish standing crops. It is the logic of this relationship that has led many to believe that the period of lowest streamflows is the single factor having the greatest impact on a stream's carrying capacity. Carrying capacity here is defined as the standing crops of fish that can be maintained indefinitely by the aquatic environment.

Substantial support for this belief is provided in the literature. Positive correlations between the magnitude of a stream's annual low flows and the variation in fish standing crops over time have been documented in numerous studies (Neave 1949 and 1958, McKernan et al. 1950, Wickett 1951, Henry 1953, Neave and Wickett 1953, Pearson et al. 1970, Burns 1971 and White et al. 1976). In Montana, such relationships have been shown for the Gallatin, Big Hole, Madison and Bighorn Rivers (Nelson 1984b, Fredenberg 1985 and Vincent in press).

Flows can increase to a level where they no longer benefit fish populations. High flows, especially those associated with floods, have been shown to adversely impact fish, with eggs and young generally affected more severely than adults (Allen 1951, Elwood and Waters 1969, Seegrist and Gard 1972 and Anderson and Nehring 1985). However, the magnitude of the impact on the population can vary by species, the time of year high flows occur and the physical stream characteristics.

Not all space in a stream is equally suited for fish. Fish tend to concentrate and spend much of their time in specific habitats, which consist, among other things, of a preferred range of bottom substrates, current velocities and water depths, and contain cover. Components of the preferred fish habitat - not all of which are readily identifiable - can vary with the species, life stage and size of fish and by stream and season.

Cover, or shelter, has long been recognized as one of the basic and essential components of fish habitat. Cover serves as a means for avoiding predators and provides areas of moderate current speed used as resting and holding areas by fish. Cover is provided by such things as undercut banks, overhanging and submerged bank vegetation, woody debris, aquatic vegetation, instream boulders and cobbles, and surface turbulence. Water depth by itself is a form of cover.

Fish habitat can be improved through artificial manipulation, thus increasing a stream's carrying capacity. One of the most cited examples occurred at Lawrence Creek, Wisconsin, where the brook trout biomass (total weight) increased almost threefold following extensive habitat improvements that increased bank cover by 416% and pool area by 289% (Hunt 1971 and 1976). Fish habitat can also be degraded by man's activities. The destruction of bank vegetation is a prime example that leads to habitat losses and, in turn, reduces the carrying capacity. For example, a study evaluating the effects of habitat manipulation on trout abundance in a small Montana stream reported that the removal of a portion of the overhanging brush cover reduced the trout biomass in a test section by 41% (Boussu 1954). It is thus well established that fish do respond, sometimes dramatically, to habitat alterations.

The amount of available fish habitat in a particular stream is strongly influenced by streamflow. This is an obvious relationship because many habitat components, such as water velocity, depth, and available bank cover, are directly affected by the magnitude of the flow (Randolph 1984 and Wesche 1973). It is through its influence on fish habitat that streamflow is believed to primarily regulate fish abundance. Greater flows expand the available habitat, allowing the fish population to increase. Conversely, following flow reductions, fish populations decrease in response to shrinking habitat. Numerous studies have documented positive relationships between fish standing crops and various indices of habitat quantity (Gunderson 1966, Lewis 1969, Stewart 1970, Wesche 1974 and 1980, Nickelson and Hafele 1978 and Loar et al. 1985b).

While streamflow primarily regulates fish standing crops through its effect on preferred habitat, other factors that can contribute to the variation in fish abundance over time are also influenced by flow. One such factor is food supply.

Aquatic insects, such as caddisflies, stoneflies and mayflies, and other aquatic invertebrates are the primary food of Montana's stream-dwelling game fish. It is widely accepted that the production of these aquatic food organisms is greatest in riffles of streams (Hynes 1970). Needham (1934) and Briggs (1948) reported that 80 percent of the invertebrate production in their study streams occurred in riffles. A riffle is a section of stream in which the water flow is rapid and shallower than the sections above and below. Streams usually consist of a succession of pools and riffles.

Aquatic invertebrates normally become available as a food source when drifting in the current, although salmonids and other fish also rely heavily at times on bottom foraging. The majority of the studies reported in the literature support the general conclusion that a strong positive correlation exists between the abundance of aquatic drift and water velocities (or stream discharge) (Chapman 1966, Waters 1969, and Everest and Chapman 1972). Increasing velocities, which are necessary to free invertebrates from the bottom substrate, should increase the quantity of drift up to the point where flows near flood levels (Waters 1969).

While increased water velocity is the generally accepted mechanism for creating drift, sufficient riffle habitat must be available to produce this food source. To sustain maximum invertebrate production, the riffle habitat should be wetted year-round because the majority of aquatic insects live from one to three years on the stream bottom before emerging as air breathing, winged forms and completing their life cycles. These organisms cannot be expected to readily re-colonize those areas that are alternately wetted, dried and rewetted each year. Thus, both the total amount of wetted riffle area and the velocities through these riffles appear to be important factors determining the quantity of drift.

The assumption that food supply can be an important factor controlling fish abundance is supported in a number of studies. Mason and Chapman (1965), Peterson (1966), Elliott (1973) and Gibson and Galbraith (1975) reported that stream sections having the higher incoming drift supported greater fish standing crops. Murphy et al. (1981) found that trout biomass at six stream sites in Oregon's Cascade Mountains was highly correlated with the biomass (in riffle samples) of the collector-gatherer group of invertebrates (r=0.99,

$P<0.01$) and moderately correlated with the total invertebrate biomass ($r=0.83$, $P<0.05$).

Fish abundance can reflect the quantity of the food supply and populations will benefit if food production was optimized. A logical means for accomplishing this goal is to maintain a flow level that wets the maximum amount of a stream's riffle area. The underlying assumption is that fish standing crops will respond to increases in wetted riffle area via the impact on food production. Support for this logic is provided by Pearson et al. (1970), who found that pools having larger upstream riffles averaged higher production of coho salmon per unit of pool area than did pools with smaller riffles. On the negative side, Cada et al. (1983) were unable to show a consistent relationship between invertebrate densities and riffle wetted perimeter at various flows for four southern Appalachian trout streams. However, they concluded that their analysis was only preliminary and, in a subsequent correspondence with the MDFWP, Cada stated that he hoped to restudy the relationship in greater detail and suspected that there was some value in examining wetted perimeter when considering flow effects on aquatic invertebrates.

Streamflow will control the amount of riffle area that is covered by water and, as a result, can influence food production. This relationship between streamflows and food production is of particular significance during the warmer months when higher water temperatures initiate fish growth and young fish are hatched and enter the population. Due to this growth and recruitment, the population increases over summer in both numbers and biomass, typically reaching its highest level in fall. The fact that populations tend to increase over summer suggests that the amount of preferred habitat needed for population expansion is in excess at this time. Vacant habitat would have to be available in order for this expansion to occur. This is consistent with the fact that streamflow in Montana's unregulated streams is normally highest in summer and lowest in winter (Figure 1). (Prairie streams, regulated streams and those heavily depleted for irrigation often violate this "rule of thumb"). Consequently, habitat availability is expected to be greatest during summer and lowest in winter. On these streams, food supply may be more influential in limiting the summer population expansion than is a lack of unfilled habitat.

In winter, Montana's streams normally exhibit high fish losses, which are attributed to the seasonally low flows coupled with the detrimental effects of sub-surface ice formation, ice scouring and other harsh physical conditions that typically characterize a Montana stream in winter. The severity of the winter environment on fish populations has been discussed by a number of authors (Maciolek and Needham 1952, Needham and Jones 1959 and Butler 1979) and borne out by the high over-winter mortality rates that have been documented for a number of Montana streams (MDFWP 1984 and Schrader 1985). By winter's end, populations are typically reduced to the lowest level of the year in response to the adverse habitat conditions. It is this winter period and its associated low flows that ultimately regulate the capacity of most Montana streams to sustain fish.

A better understanding of the connection between food supply and winter habitat in regulating fish abundance is provided by Mason (1976). He was able, through supplemental feeding, to increase the summer biomass of juvenile salmon in a small British Columbia stream by 6-7 fold when compared to natural levels. However, the over-winter loss of these fish was extremely high, resulting in a spring population that was numerically similar to the population under natural conditions (no supplemental feeding). This study

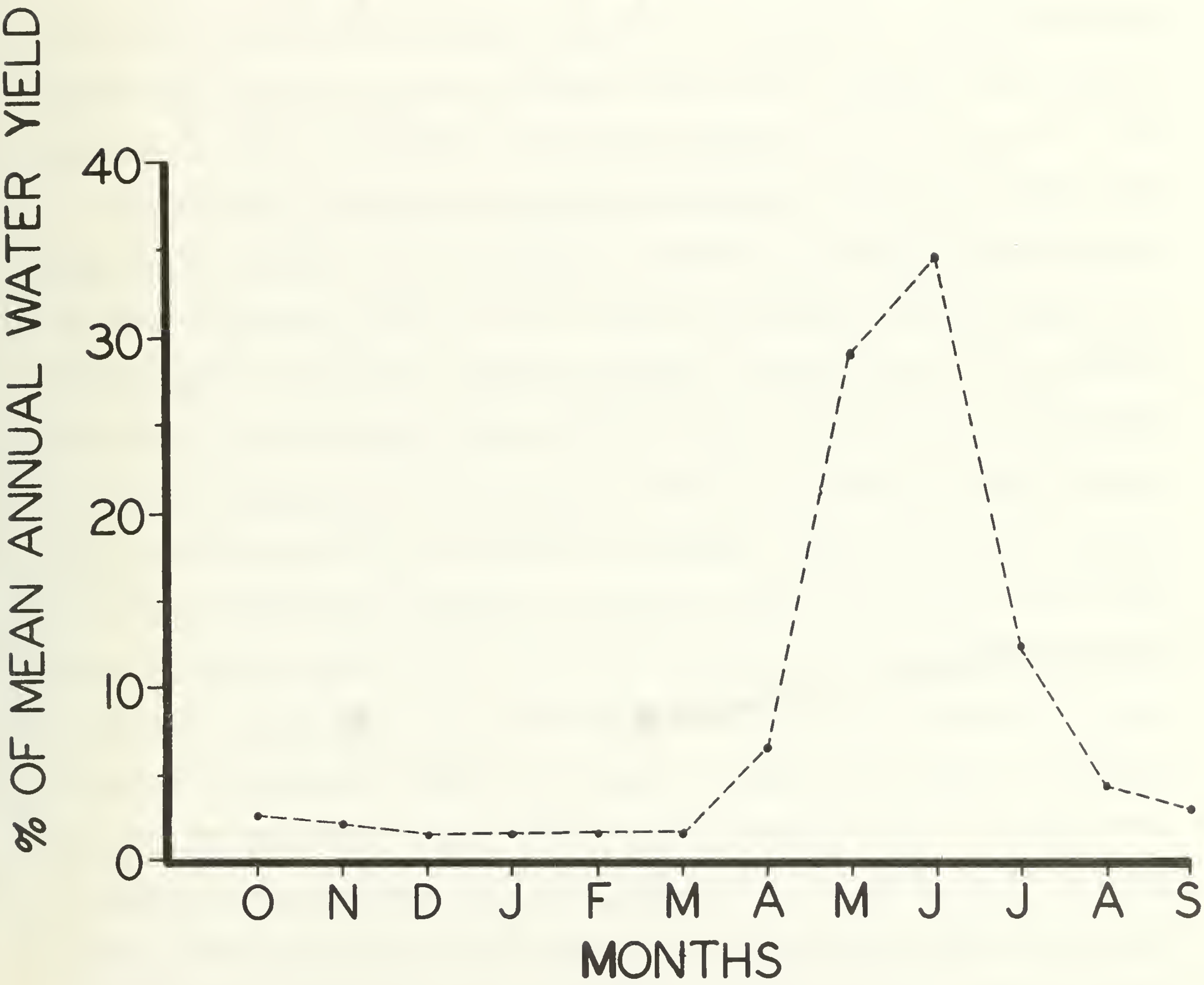

Figure 1. Monthly water availability for mountain trout streams in Montana. The monthly values are the averages for five unregulated streams east of the Continental Divide.

demonstrated that food supply was the most important factor controlling population size in summer, but physical habitat conditions in winter ultimately limited the population and prevented a high carry-over of fish from the previous summer's supplemental feeding.

The role of habitat in regulating fish abundance in Montana's streams is probably dominant in winter and of lesser importance in summer when food supply likely plays a key role. During the transition period between summer and winter when flow levels start to approach the winter lows (Figure 1), habitat should begin to play a more prominent role in controlling population size. As natural flows progressively decline, a theoretical point is reached when habitat reductions overtake food supply as the primary limiting factor. Justification for habitat becoming a key limiting factor prior to the winter low flow period being reached is based on the fact that the habitat needs of individual fish are generally considered greatest during the warmer months when fish grow, reproduce, and actively defend territories. In winter, escaping from the rigors of the harsh physical environment appears to be the primary life function. For protection, wintering fish tend to seek out the deeper pools, enter the bottom substrate or congregate amid heavy accumulations of brush and debris (Chapman and Bjornn 1968). Because wintering fish typically confine their activities to limited areas and are less active, their individual habitat requirements appear to be less than their non-winter requirements. Thus, a greater flow is needed in the warmer months than is required during winter to support the same fish abundance. Stated another way, a given flow should provide less fish habitat during the warmer months than in winter. (This generality applies only to those time periods when sub-surface ice is not the dominant determinant of channel structure.)

Habitat undoubtedly plays a crucial role in limiting populations during the non-winter months in those streams in which flows are depleted for irrigation. The habitat reductions that result when irrigation water is removed, especially in late summer and fall when natural flow levels have dropped considerably, become more limiting to the population than the food supply and, if flow depletions are severe, replace winter habitat as the ultimate population control. Data collected for the Gallatin, Big Hole and Shields Rivers - Montana streams that are severely depleted for irrigation - suggest that the summer low flow has become the ultimate population regulator on portions of these three streams (Nelson 1984b and Clancy 1985).

How streamflow regulates populations during the non-winter months - via food supply, habitat or a combination of both - is less relevant than the fact that regulation does occur. As a result, there are distinct benefits to maintaining non-winter flow levels that exceed the winter lows. One important benefit is that the higher flows of the non-winter period allow the population to achieve maximum growth and expansion over summer, providing anglers with a harvestable surplus of fish before the upcoming, winter, population adjustment. Anglers have the opportunity to take a portion of the fish biomass that will normally be lost over winter, without materially impacting future fish abundance. Maintaining flows year-round at the low level of winter would not allow for this summer expansion and would, therefore, diminish or eliminate fishing opportunities. Another real possibility is that a year-round low (winter) flow would reduce the fall population to a level below the carrying capacity of the winter habitat, and thus lead to a major reduction in future fish abundance. This stems from the likelihood that habitat requirements of individual fish may be greater in the warmer months than in winter. Clearly, neither fish nor fishermen would benefit if flows were maintained year-round at their low winter levels.

While streamflow is often considered the most important variable regulating fish densities, its influence can be masked or overridden by other controlling factors, such as man-caused pollution and the over-harvesting of fish by anglers. In these situations, fish standing crops are suppressed by factors unrelated to flow and held at a level far below the habitat's carrying capacity. The influence of flow levels, therefore, becomes secondary except possibly under severe low flow conditions. If these other controls were reduced or eliminated, streamflow would again become the dominant population regulator.

When deriving flow recommendations for Montana's streams, fishery managers strive to provide a level of protection that will maximize fish populations. Given this goal, a prudent and defensible approach is to fully protect winter flows. Flow reductions during the winter low flow period would only serve to aggravate an already stressful situation for fish (MDFWP 1984), potentially leading to even greater over-winter losses. For the remainder of the year, a reasonable strategy is to provide a flow that maintains food production and fish habitat at a level which maximizes the growth of individual fish and the expansion of the population over the summer growing season.

SURVEY AND ANALYSIS OF INSTREAM FLOW METHODS

Survey of Available Techniques

Probably the best and most defensible method for determining streamflows necessary to maintain existing aquatic resources is to observe responses of fish populations to changing flow regimes in a specific water over a period of years. While this approach is desirable, it is impractical for use on a broad scale because of time and manpower requirements. The need to collect data over a wide range of annual flow conditions is an additional constraint since researchers seldom have control over this variable. Although such information exists for a few of Montana's "blue ribbon" trout streams (Nelson 1980a and 1980b), it is not a viable alternative to the commonly used IFM's.

Recent reviews by Wesche and Rechard (1980), Loar and Sale (1981), and Trihey and Stalnaker (1985) have shown that the commonly used and accepted instream flow methods can be classified into three categories. They will be referred to as:

1. Non-field
2. Habitat retention
3. Incremental

Non-Field Methods

The first category includes a variety of "non-field" methods that set minimum flows based on existing historical streamflow records. One of the most common of these is the Tennant Method, also known as the Montana Method. The name "Montana Method" is a misnomer because it is not the preferred method in the MDFWP's program to set instream flows. This method derives flow recommendations based on percentages of the mean annual flow for the stream in question. Other related methods are based on manipulations of water yield or flow duration information. All such methods are similar in that they are usually performed in the office using existing hydrologic information with few, if any, on-site visits required.

Habitat Retention Methods

The second group of IFM's includes a wide array of techniques that examine relationships between discharge and generalized fish habitat indices to derive flow recommendations intended to maintain the stream resource at a desired level. They are called "habitat retention" methods because they specify flow levels where certain desirable aquatic habitat characteristics (such as riffle wetted perimeter) are retained. These methods require one or more visits to the stream or river where habitat measurements are made along established cross-sectional transects. Some methods employ hydraulic simulation models (such as Manning's equation or stage-discharge relationships) while others rely on repetitive measurements made at several different flows.

Habitat retention methods commonly apply criteria to define flows necessary to provide suitable conditions for one or more of the following life functions:

1. unimpeded passage to spawning areas
2. adequate spawning habitat
3. adequate rearing habitat
4. adequate food producing habitat.

For example, the Oregon Method addresses fish passage requirements by examining water depths and current velocities over a range of flows at several transects. These transects are established across critical riffles where fish passage problems would first appear as discharge decreases. Criteria developed for various fish species from field observations and laboratory studies are then compared to cross-sectional information to identify flows where channel width, water depth, and current velocity conditions no longer allow adequate passage. Depth and velocity passage criteria for a variety of fish species were presented by Thompson (1972). Similarly, several habitat retention techniques use either species-specific or generic depth and velocity criteria and carefully placed cross-sectional transects to derive flow recommendations for known spawning areas (Wesche and Rechard 1980).

While not all of the habitat retention methods described by Wesche and Rechard (1980) consider passage and spawning requirements, they do share a common emphasis on defining flows required to provide adequate fish rearing habitat. However, as pointed out by Thompson (1972), the identification of appropriate rearing flows is far more difficult than determining passage and spawning flows. Fish habitat requirements for rearing purposes are complex because preferences for water depth, velocity, cover, and substrate usually vary not only between species but also between life stages (i.e., fry, juveniles, adults) of a single species. Further, the habitat requirements (primarily current velocity, substrate and depth) of the numerous species of aquatic macroinvertebrates that comprise the main food base for trout in most streams also vary significantly between species.

Because rearing habitat requirements of lotic fish species and food organisms are so complex and interrelated, the habitat retention IFM's typically evaluate the relationship between streamflow and some general index of habitat condition to make flow recommendations. Many of these methods focus on riffles because of their importance as food producing areas and the belief that the maintenance of riffles will provide adequate amounts of habitat in other areas of the stream (Stalnaker and Arnette 1976). As shown in Table 1, four of the seven common "habitat retention" methods specifically consider riffle habitats and five methods give at least some consideration to the amounts of wetted perimeter retained in the stream.

Incremental Methods

The third group of IFM's can be referred to as "incremental." These techniques produce habitat-discharge relationships for specific life stages of various fish species. They are termed "incremental" methods because they attempt to predict the actual amount of suitable fish habitat present as flow changes incrementally. The "California Method" for rainbow trout and the "WRRI Method" for brown trout (both described by Wesche and Rechard 1980) are included in this group. However, the best known technique is the Instream Flow Incremental Method (IFIM). IFIM is the most advanced instream flow method and it continues to be refined by the CIFSG at Fort Collins, Colorado.

The IFIM has been described in detail elsewhere (Trihey and Wegner 1981, Bovee 1982, Milhous et al. 1984). Loar and Sale (1981) describe the method as follows:

> "A package of computer programs, collectively called PHABSIM (Physical HABitat SIMulation system), is used to implement this analysis of instream flow needs. The overall approach combines (1) multiple-transect field data from a representative and/or critical river reach, (2) hydraulic simulation models to predict physical habitat parameters such as mean velocity (v), depth (d), and substrate (s), and (3) species-specific suitability functions (S_v, S_d, S_s). Suitability functions are used to calculate weighting

Table 1. Summary of the common "habitat retention" methods used to determine rearing flow requirements (derived from Wesche and Rechard 1980).

Method	Species	Habitat Unit Considered	Rearing Criteria
Oregon	salmonids	riffles	- adequate depth - 60% wetted - velocity 1.0 to 1.5 ft/sec
		pools	- velocity 0.3-0.8 ft/sec - pool-riffle ratio near 50:50
Colorado (USFS Region 2)	salmonids	riffles	- 50% wetted - average velocity 1.0-1.5 ft/sec - depth 0.2-0.4' if width less 20' 0.5-0.6' if width more 20'
USFS Region 4	salmonids	all units (pools, riffles, runs, etc.)	- numerical rating system for pool quality, pool structure, streambed and bank environment
USFS Region 6	salmonids	"typical rearing habitat"	- depth 0.5-3.0 ft - velocity 0.2-1.6 ft/sec
		"food producing habitat"	- depth 0.1-3.0 ft - velocity 1.0-4.0 ft/sec
Washington	salmonids	riffle/pool sequence	- inflection point on wetted perimeter: discharge curves
Idaho	warmwater	riffles	- inflection point on wetted perimeter: discharge curves
Montana's WETP	salmonids	riffles	- inflection point on wetted perimeter: discharge curves

> coefficients representing the habitat preferences of various life stages of target fish species. Finally, measures of habitat suitability and availability (as wetted surface area, a_i) are used in computation of Weighted Usable Area (WUA), an index of habitat condition. This index is computed for each life stage [e.g., spawning (S), fry (F), juvenile (J), and adult (A)] and can be plotted against discharge" (Figure 2).

A major difference between IFIM and the "habitat retention" methods is that it builds a three-dimensional model of a stream section while the other methods usually examine habitat characteristics only on discrete cross-sectional transects (two-dimensional modeling). IFIM divides the study section into a matrix of rectangular cells (Figure 3) and uses either a single-flow (WSP-type model incorporating Manning's equation) or a multiple-flow stage-discharge hydraulic modeling approach to describe flow-related changes in depth and velocity within each cell. Once the hydraulic model for each cell is constructed, habitat suitability curves are consulted to determine habitat suitability for a given life stage of a given species for each flow of interest.

Example habitat suitability curves for velocity, depth, and substrate are shown in the upper right on Figure 2. Suitability factors range between 0.0 (most unsuitable) and 1.0 (most suitable). A composite habitat suitability factor is determined for each cell in the study section at each flow of interest by multiplication of factors for depth, velocity, substrate and/or cover. This composite suitability factor also ranges between 0.0 and 1.0 and it is multiplied by the surface area of the cell to determine the "usable" area in the cell at a particular flow. These values are tabulated for all

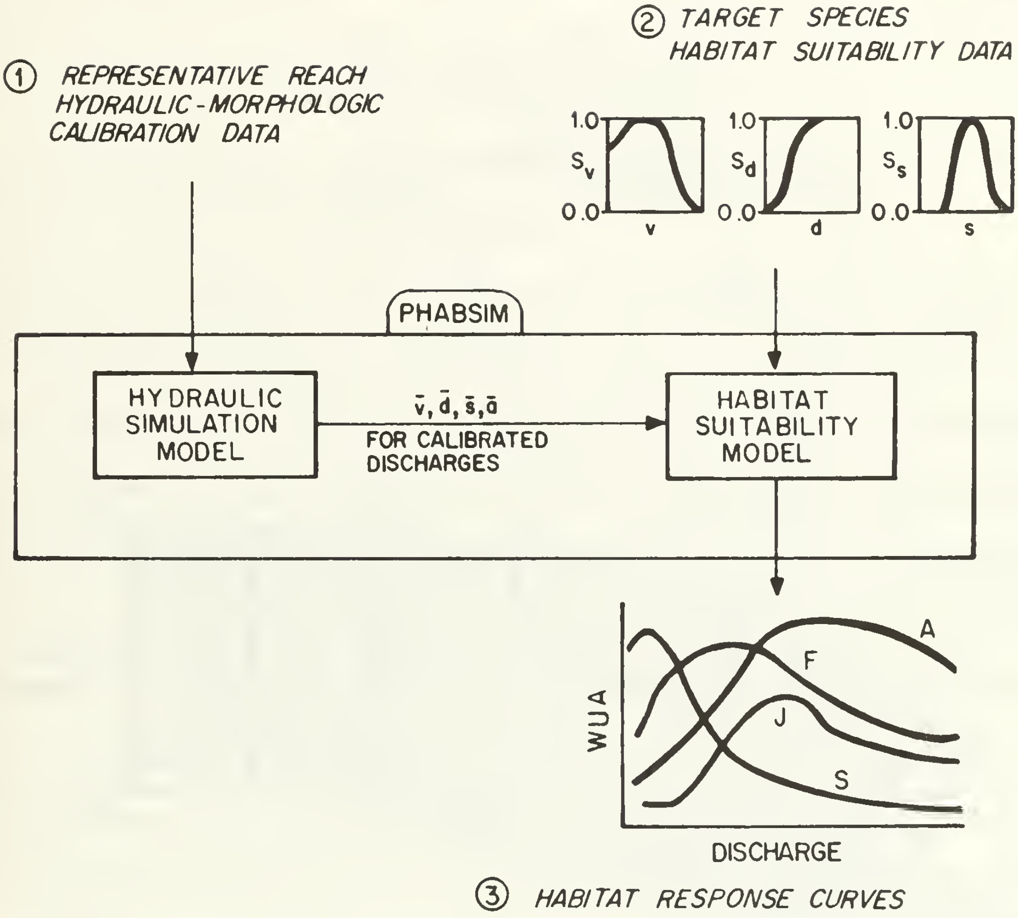
① REPRESENTATIVE REACH HYDRAULIC-MORPHOLOGIC CALIBRATION DATA
② TARGET SPECIES HABITAT SUITABILITY DATA
1.0
S_v
0.0
v
1.0
S_d
0.0
d
1.0
S_s
0.0
s
PHABSIM
HYDRAULIC SIMULATION MODEL
$\bar{v}, \bar{d}, \bar{s}, \bar{a}$
FOR CALIBRATED DISCHARGES
HABITAT SUITABILITY MODEL
WUA
A
F
J
S
DISCHARGE
③ HABITAT RESPONSE CURVES

Figure 2. Organization and information processing in the Instream Flow Incremental Method (IFIM) for instream flow assessment (from Loar and Sale 1981).

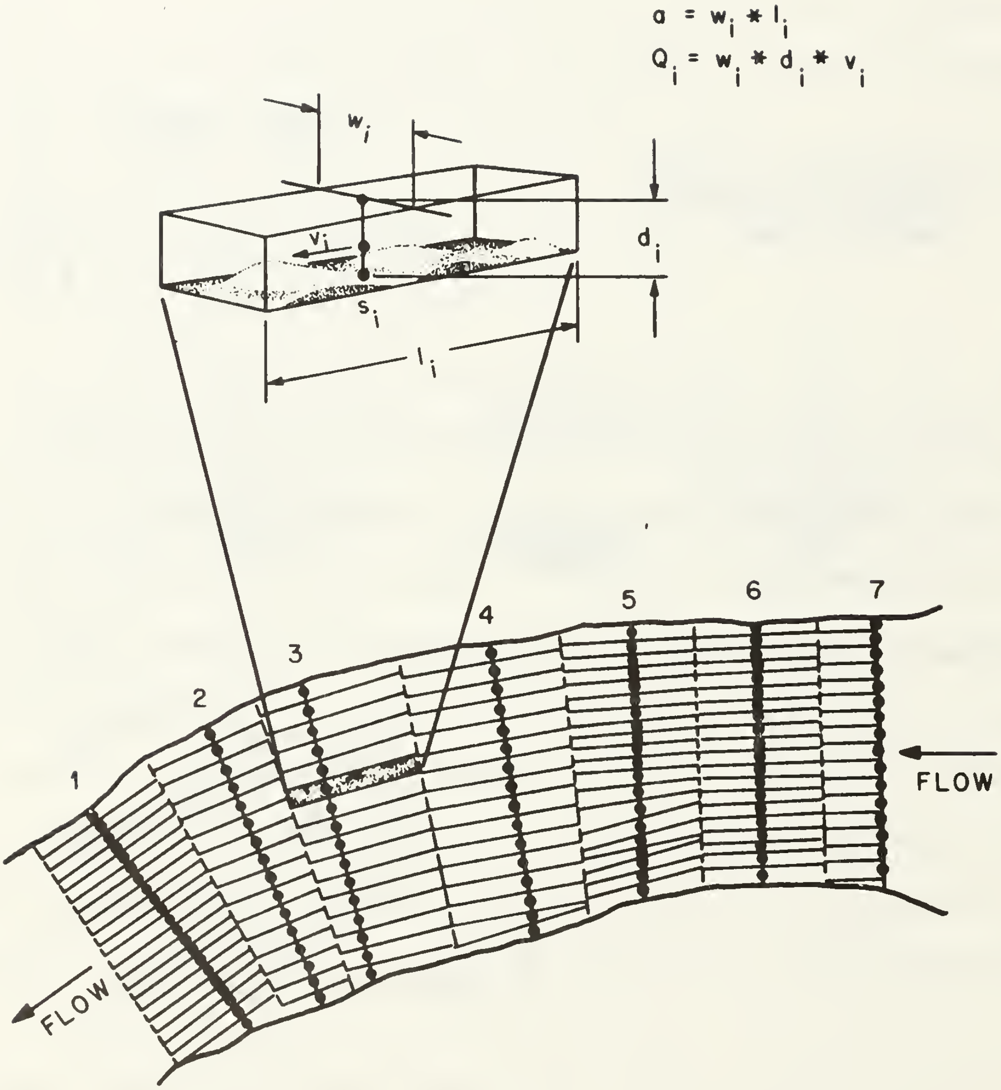

Figure 3. Subdivision of a stream reach into transects and mapping cells for computational purposes with the Instream Flow Incremental Method (IFIM) (from Loar and Sale 1981).

cells in the study section to determine total weighted usable area (WUA) at a given flow for a life stage of a species (i.e., WUA for rainbow trout fry in stream section "x" at 13 cfs). Using habitat suitability curves and depth and velocity predictions from the hydraulic model, graphs of WUA versus discharge for various life stages of a fish species can be generated (i.e., lower right in Figure 2).

Advantages and Limitations of IFM's

There are a number of IFM's that can be employed to determine the instream flow needs for fishery resources. Wesche and Rechard (1980) listed 11 common techniques, many of which are still in use. There is no consensus on which method is the most appropriate to uniformly apply in all situations. Such a consensus may not be possible because of regional differences in instream flow program structures and goals, hydrology, channel morphology, fish community structure and habitat use, available funding, and continuing advances in the "state-of-the-art" of instream flow analysis.

Because there is no "best" method to determine instream flows to meet fishery needs under all conditions, the following discussion will examine the assumptions, strengths, and limitations of the main IFM's. The interested reader is encouraged to consult the excellent review by Loar and Sale (1981) since much of the following is derived from that source. Since the main objective of this report is to evaluate Montana's wetted perimeter inflection point method, particular attention will be paid to this technique.

We will discuss the advantages and limitations of the various IFM's with regard to the following main subject areas: hydraulics and channel morphology, decision-making capabilities, and data and manpower requirements. Many of the IFM evaluation studies conducted to date will be discussed with particular attention paid to assumptions and experimental design. Finally, the results of studies that evaluate the effectiveness of Montana's wetted perimeter method are summarized, and criteria for selecting a particular IFM are discussed.

Hydraulics and Channel Morphology

The ability of various IFM's to account for differences in channel morphology between watersheds or even individual stream reaches is an important consideration. The "non-field" IFM's have the least ability to compensate for such differences because they do not rely on site-specific relationships between habitat and discharge. For example, the Tennant Method (probably the most widely used non-field IFM) assumes that a certain percentage of mean annual flow will provide adequate channel width and depth to maintain aquatic resources at some desired level. However, watershed geomorphology investigations have identified a number of variables besides flow frequency (such as watershed area, geology, slope, age, and stream order) that play important roles in determining stream channel and flow characteristics. These variables have been shown to vary significantly between watersheds but none of the common "non-field" IFM's address this problem (Loar and Sale 1981). Hence these methods are best suited to relatively homogeneous watersheds where assumptions concerning channel geometry are met.

The "incremental" and "habitat retention" IFM's utilize site-specific habitat measurements that account for differences in channel morphology between watersheds or stream reaches by developing habitat-discharge relationships for each stream reach. To develop these relationships, some form of hydraulic model (either empirical or mathematical) is used. Each type of hydraulic model is based on certain assumptions and has certain advantages and limitations.

Empirical relationships between habitat and discharge are derived by direct habitat measurements made over a range of observed flows. This is a simple and straightforward approach but it involves extensive time and manpower investments and offers limited ability to predict habitat characteristics at unobserved flows. Trihey and Baldridge (1985) recommend an empirical approach for high gradient streams with complex hydraulic features, but their method requires three to ten field visits to develop acceptable habitat-discharge relationships. The need for a large number of site visits is common with empirical approaches because habitat-discharge relationships are seldom linear, thus necessitating numerous "points" (data sets) on graphs to adequately describe these relationships. Extrapolation between and beyond observed test flows can be a questionable practice if empirical field data are inadequate to properly describe the shape of habitat-discharge curves.

Mathematical models are used by many of the field-oriented IFM's to (1) reduce the amount of field effort required, (2) provide more ability to extrapolate between and beyond test flows, and (3) to attach some statistical confidence to habitat predictions. Three general types of hydraulic models are typically used. The simplest and most direct hydraulic models are those based on stage-discharge relationships generated by regression techniques. These relationships are commonly derived from field measurements made at three different flows, although accuracy can be improved by additional measurements. In certain instances, measurements can be made at two flow levels but significant "two-point" errors can result (Bovee and Milhous 1978).

Several "habitat retention" IFM's such as the R2-Cross, or Colorado, Method utilize a second type of hydraulic model based on Manning's equation.

This model develops a simulated stage-discharge relationship for a given cross- section based on field measurements of cross-sectional area, hydraulic radius, energy slope, and channel roughness at a single discharge. This method is advantageous because it entails only one set of field measurements. However, it is not well suited to natural stream channels where flow conditions are not always uniform. Manning's equation was developed to describe flow conditions in manmade channels where energy slope and channel roughness (Manning's "n") remain relatively constant as flow changes. These coefficients often vary significantly in natural channels as discharge changes, thus reducing the accuracy of the predicted stage-discharge relationship (Bovee and Milhous 1978). Consequently, for most natural stream channels, more accurate stage-discharge relationships will be obtained using regression procedures and three (or more) sets of calibration data. The regression approach also allows extrapolation over a greater range of flows (Bovee and Milhous 1978). For these reasons, Montana's wetted perimeter method employs a stage-discharge hydraulic model using a regression procedure and usually three sets of stage and discharge measurements.

"Step-backwater" models comprise the third main group of hydraulic models used in IFM's. The most well known of these models is the WSP (Water Surface Profile) model. This method produces three dimensional depth and velocity maps of a stream section using Manning's equation and the Bernoulli Energy Equation. It can be applied using only one set of field measurements, but its accuracy and range of extrapolation can be enhanced by one or more additional sets of field data (Bietz et al. 1985). Step-backwater models require more precise and detailed field survey data and also require accurate and mandatory placement of transects across all hydraulic control points in the study section. IFIM is the most flexible IFM in terms of hydraulic modeling because it allows the use of empirical, regression, or step-backwater procedures as well as combinations of the latter two.

Decision-Making Capabilities

All the various IFM's have advantages and disadvantages in terms of ease of interpretation for decision making, ability to "customize" flow recommendations, and defensibility of decision criteria and processes. Trihey and Stalnaker (1985) identified two types of IFM's that relate to decision-making capabilities. They are the "standard setting" methods and the "incremental" methods. What we've called "non-field" and "habitat retention" methods are standard setting methods. These methods identify minimum flow standards that may constrain development, whereas incremental methods (of which IFIM is the best known) quantify tradeoffs by examining fish habitat responses to flow alterations.

The standard setting methods are by far the easiest to interpret for making decisions since they are concerned with setting minimum flows, whether it be for spawning, passage, incubation, rearing, or food production. However, because these methods recommend minimum flows they can actually compromise some portion of the aquatic resource if these minimum flows are all that is maintained during the period of recommendation. Trihey and Stalnaker's (1985) analogy was that fish communities may be able to withstand near-drought conditions for one year in ten (or one month per year), however, standard setting methods may impose such conditions for 10 out of 10 years (or all months of the year). This could have serious unanticipated biological consequences because fish and other aquatic organisms are complexly adapted to, and in many cases depend on, natural variations in streamflow.

IFIM can compensate for this problem to some degree because it can develop complex seasonal flow recommendations for several life stages of many species if adequate hydrologic and habitat suitability data are available. In this regard it is a superior method to the "habitat retention" methods that consider flow-related changes in only one (such as riffle wetted perimeter) or a very few habitat components to indicate overall ecosystem response. The ability of IFIM to generate complex seasonal/species/life stage-specific flow recommendations can also be a limitation. At times, an almost overwhelming amount of information can be generated, creating problems with data synthesis and determination of recommended flows. Problems that must be addressed include determining which life stage is most limiting to a species, and which life stage of which species is most important during a given season. These difficult decisions often require "professional judgment" and are necessary because a flow that is beneficial to one life stage of a given species may be detrimental to other species or to other life stages of the same species.

The various procedures used by IFM's to derive the final flow recommendation(s) offer certain advantages and limitations. The simplest and most direct procedures are employed by the "non-field" methods that simply select percentages of annual flow or some other measure of flow frequency. While this approach lacks biological sensitivity, the mechanics of deriving the flow recommendations are relatively unassailable.

The approaches used by various "habitat retention" IFM's to derive final flow recommendations are the source of some controversy. Two approaches are typically used. The first uses habitat criteria for such things as depth, velocity, width, and wetted perimeter as shown previously in Table 1. For example, the Oregon method specifies that minimum flows for salmonid rearing must provide adequate depth in riffles, cover approximately 60% of riffle area by flow, provide 1.0 to 1.5 feet/sec riffle water velocity, provide 0.3 to 0.8 feet/sec pool water velocity, and must produce a pool:riffle ratio of 50:50 (Thompson 1972). The second approach relies on the identification of inflection (or breaking) points on habitat-discharge curves to identify critical flows below which habitat losses increase rapidly.

Loar and Sale (1981) and Annear and Conder (1984) criticized the inflection point approach as being too subjective and having the potential to "create rather than alleviate controversy over water allocation needs." Loar and Sale (1981) recommend using habitat criteria because they "are much less ambiguous than inflection-point calculations and are preferable because the value judgments are clear and relatively more defensible." However, Bietz et al. (1985) presented an entirely opposite argument and rejected the use of habitat criteria because none of the parameters have been directly related to habitat quality. They further state: "The relationship between percent (emphasis added) wetted perimeter retained and aquatic habitat quality is even more tenuous. Unlike the wetted perimeter inflection point, there is no currently available rationale for claiming that a fixed percentage of wetted perimeter represents an acceptable or non-acceptable level of aquatic habitat retention."

As emphasized by Loar and Sale (1981), all IFM's involve some level of subjectivity, and professional judgment is essential to formulate final flow recommendations. Inflection point methods require judgment in selecting inflection point flows, while methods employing habitat criteria require judgment in defining the criteria to use. The selection of inflection points is often very simple and requires little professional judgment. However, in some cases the biologist must use judgment to select inflection point flows that will provide adequate habitat for the existing aquatic resource. To employ habitat criteria, the judgment has to be made by the biologist at the outset, but it should not be construed as being any less subjective than that employed in selecting inflection points.

Data and Manpower Requirements

Each IFM has specific requirements for streamflow gaging information, field transect data, and site-specific habitat suitability data for target species. In Montana, the requirements for flow gaging information are critical because most of the stream reaches involved in water allocation proceedings have no gaging records. The habitat retention IFM's are best suited for ungaged streams since they require little or no long-term flow information and also involve one to three or more visits to the site. Flow measurements and channel morphology observations made during these visits give the biologist some idea of the annual hydrologic regime and a "feel" for the flow-related changes in fish habitat quality and quantity.

Many of the non-field IFM's require long-term streamflow records. However, mean annual flow of many streams can be adequately estimated using watershed analysis techniques requiring little or no fieldwork. The Tennant method (a non-field method based on percentage of mean annual flow) can, therefore, be used in the absence of good streamflow records, provided mean annual flow can be accurately predicted from basin characteristics. Long-term hydrologic information is considered essential by the CISFG to negotiate flow recommendations using IFIM.

The non-field IFM's typically require little or no transect information gathered on-site. On the other hand, the habitat-retention and incremental methods often require extensive amounts of transect data at several flows. Field data requirements for habitat retention methods can be substantial if passage, spawning, and rearing flow requirements all need to be determined. This could require two or more sets of transects in different habitats that would each need to be visited three or more times and possibly at different seasons. Montana's wetted perimeter inflection point method is one of the simplest field methods because it requires only three sets of water surface elevation data and one set of channel profile measurements at each transect. In contrast, many other habitat retention methods, as well as IFIM, require depth, velocity, substrate and/or cover measurements at numerous points across each transect for each visit to the site.

Habitat suitability curves for species of interest are essential to the application of IFIM as discussed previously and illustrated in Figure 2. Originally, preferences for depth, velocity, substrate, and cover for a single life stage of a species were thought to be similar in all streams. Hence, suitability data gathered in one stream would be transferrable to others, thus saving additional time and effort. However, problems in applying IFIM in some areas have been traced to the fact that fish may not use habitat equivalently in different stream environments (Nelson 1980c, Annear and Conder 1983). Moyle and Baltz (1985) recommend developing habitat suitability curves on-site for each species of interest because variations in fish population densities and species composition within and between streams can lead to differences in habitat use via intra- and inter-specific competition. Also, well known diurnal and seasonal habitat preference shifts can seriously complicate the use of IFIM (Campbell and Neuner 1985). Perhaps the best solution to this problem is to identify which limiting factors operate during each season to regulate fish populations and then focus instream flow analysis and habitat criteria on these conditions (Campbell and Neuner 1985). If site-specific habitat preference data are indeed mandatory, the costs and time involved in IFIM applications become very high.

Manpower requirements vary significantly among various IFM's and have been discussed in detail by Wesche and Rechard (1980) and Loar and Sale (1981). The "non-field" methods typically require little or no fieldwork and can usually be completed with less than one man-day of office effort. Manpower requirements are highly variable between "habitat retention" methods and depend upon which method is used and what life functions (spawning, incubation, passage, rearing) are considered. According to Wesche and Rechard (1980), the Oregon Method requires 3-6 man-days of field effort and 1-3 man-days of office work to derive recommendations for each of three functions: spawning, passage, and rearing. The Washington Method requires much more effort (man-days): 10-20 field days and 15-30 office days for spawning; the same for rearing; and 5-10 field days and 1-3 office days for wetted perimeter. The Montana wetted perimeter inflection point method requires relatively little manpower - about 4-6 man-days in the field and ½-1 man-days in the office. None of the above manpower estimates include travel time.

As might be expected, IFIM has very high manpower and training time requirements. Loar and Sale (1981) estimated that IFIM would typically require up to ten times the manpower as the simpler habitat retention methods such as the Colorado (R2-Cross) Method and Montana's wetted perimeter inflection point method. In addition to manpower, the training costs for IFIM are very high compared to other methods. The USFWS conducts a mandatory series of 4-5 short courses to train IFIM users. These courses involve 150-170 hours of training and cost $1,500-$2,000 to complete, excluding salary, travel, and lodging expenses. In addition, access to IFIM computer software is extremely limited for non-federal personnel.

IFM Evaluation Studies

The question of how effective various IFM's are for determining instream flow needs for maintenance of fisheries and other aquatic resources is one of the most important issues facing fisheries biologists today, yet remains the most difficult to resolve. Although many studies have been published that "evaluate" one or more IFM's (e.g. Nehring 1979, Prewitt and Carlson 1979, Stalnaker 1979, Hilgert 1981, Orth and Maughan 1982, Annear and Conder 1983 and 1984, Bietz et al. 1985), most of them are deficient because they tended to focus on the mechanics of the models used, or the uniformity of the results, rather than on the biological adequacy of the instream flow recommendations.

The problem of relating the results of various IFM applications directly to fish populations was recognized by Wesche and Rechard (1980), who stated, "the fallacy of the 'state of the art' has been that no methodology, no matter how detailed, addresses the question of potential biological consequences." The following statement by Trihey and Stalnaker (1985) indicates that we continue to face this dilemma:

> "Despite the successes, fisheries biologists have not yet achieved the capability of forecasting the number of fishes produced in response to any particular water management scheme. This question is being brought up more and more in present-day water development and constitutes a third phase. Within the next decade or so a scramble is expected for research and method development aimed at predicting changes in numbers of fish resulting from flow and channel alterations. This will be similar to the 1970's when methods to quantify the response of fish habitat to streamflow were developed. Only after reaching this third phase can we begin to quantify the economic value of altering the instream resource. This will provide an equivalent basis for comparison of fishery resources with other instream/out-of-stream values."

Our present inability to thoroughly evaluate the adequacy of instream flow recommendations is related to two major difficulties. These are: (1)

lack of a thorough understanding of the carrying capacity of lotic systems and how various factors operate to limit carrying capacity, and (2) problems with experimental design. Both of these problems are complicated by the fact that aquatic ecosystems are comprised of complex assemblages of organisms that interact with one another as well as with their physical environment (Giger 1973). Further, these interactions may vary seasonally, between life stages of a species, and between stream environments.

Carrying Capacity and Limiting Factors

A persistent problem that hampers efforts to successfully evaluate and apply IFM's is the knowledge of what the carrying capacity of the stream is, whether or not fish populations are at carrying capacity, and what factor(s) act to regulate carrying capacity. Although the concept of carrying capacity may be simply defined (the standing crops of fish that can be maintained indefinitely by the aquatic environment) the controlling mechanisms are not easily quantified. Carrying capacity is determined by the action of one or more limiting factors.

Giger (1973) reviewed a number of publications and agreed with McFadden (1969) who concluded that it was impossible to identify any one factor that exclusively regulated populations of early trout and salmon life stages (fry and juveniles). Rather, a number of factors interact to regulate fish populations and "each factor can be understood properly only within the context of the network of relationships" (Giger 1973). It is likely that limiting factors vary between streams due to differences in species composition, hydrology, climate, and habitat.

There is general agreement among researchers that in most cases physical habitat during the late summer, fall, and winter months when streamflows are at annual lows is the primary factor limiting fish populations in western coldwater streams and rivers (Wesche and Rechard 1980, Giger 1973). Loar and Sale (1981) suggest that fish habitat may be a limiting factor only during very high or very low flow conditions. They further state that at intermediate flows when habitat availability is high, other factors such as food production may become more important as limiting factors. It is obvious that continued research is needed to develop consistent methods to identify limiting factors so that instream flow recommendations can be better tailored to suit differing seasons and stream environments (Campbell and Neuner 1985).

Experimental Design

Based on a review of available literature, three main approaches have been used to evaluate the adequacy of various IFM's for making appropriate instream flow recommendations. These are:

(1) Approaches that examine short-term relationships between streamflow or some habitat index (such as weighted usable area (WUA) derived using IFIM) and fish population size or standing crop.

(2) Approaches involving experimental manipulations of flow and fish populations or standing crops.

(3) Long-term studies of relationships between flow regimes and fish populations or standing crops.

Each of the above approaches has certain advantages and limitations. The first is probably the least suitable for evaluating IFM's. At least two studies (Stalnaker 1979, Annear and Conder 1983) have examined the relationships between WUA (a measure of habitat quantity) and trout populations in several streams at one point in time, typically during the low flow period when habitat is assumed to be limiting. While this approach does offer some insight into the ability of IFIM to quantify amounts and quality of fish habitat, it does little to address the question of the adequacy of IFIM's flow recommendations. The relevance of this approach in addressing the first question (relationship between WUA and fish population size) is questionable since one must assume that the fish populations were at carrying capacity during the one point in time when populations were estimated. This assumption is seldom tested, primarily due to a lack of rapid and accepted assessment techniques.

A similar approach was utilized by Orth and Maughan (1982) who examined relationships between WUA and biomass of several fish species in riffle areas of a warmwater stream during two consecutive summer low flow periods. Although significant positive correlations were observed, their work was strongly criticized by Mathur et al. (1985), primarily on the grounds of small sample size and assumptions concerning carrying capacity. Irrespective of these criticisms, the short-term nature of such studies and the lack of any *a priori* knowledge of what the minimum flow should be renders them ineffective in truly evaluating the adequacy of IFM recommendations.

The study by Kraft (1972) illustrates the pitfalls that can be encountered by short-term studies where carrying capacity is not taken into account. In this study (conducted in southwest Montana), responses of a wild brook trout population were related to manipulated flows in a natural stream channel. The results indicated that significant dewatering (up to 90%) during a three-month, summer, low flow period had little effect on trout populations or biomass.

Kraft's results are somewhat surprising in view of the abundant evidence (both experimental and intuitive) supporting the contention that the flow regime plays a major role in regulating fish populations. Shortcomings in

Kraft's study that may explain these anomalous findings are that no attempt was made to determine (1) whether the stream was at carrying capacity, (2) what factor(s) limited the population, and (3) what the long-term effects of such a flow regime might be. (Another possible, although unproven, explanation that would support his findings is that brook trout are more tolerant of low flows than are other trout species.) Kraft's study apparently contained the only evidence that Mathur et al. (1985) could provide to support their suggestion that "short term" reductions in flow may not affect fish population size.

The second IFM evaluation approach involves the manipulation of fish populations and flow regimes in experimental channels. Examples of such designs are studies by Easterbrooks (1981), White et al. (1981), and Randolph (1984). A unique and key ingredient of these studies is the attempt to insure that initial fish population levels are at carrying capacity. This is accomplished by oversaturating the habitat with introduced fish, then allowing the population to reach equilibrium (via emigration) prior to dewatering.

This is a conceptually appealing method to examine responses of fish populations (at carrying capacity) and habitat to streamflow reductions, but it also has shortcomings. Randolph (1984) suggested that equilibrium fish population size before and after such experiments may be affected by initial stocking density. While this phenomenon obviously creates some "accounting" problems, it may not significantly affect the overall study objective, which is to identify critical flows and habitat conditions below which the streams' ability to support a healthy aquatic resource rapidly diminishes. Other limitations to this study design are that (1) only one (or a few at most) stream channel is examined, (2) investigations are usually confined to one flow regime during one period of the year (i.e., late summer low flow), and

(3) it is not applicable to larger streams and rivers because of logistical difficulties.

The third approach to IFM evaluation involves the examination of fish-flow information collected over a period of years on one or more streams. This empirical approach overcomes many of the shortcomings inherent in short-term and/or experimental studies, but it too has limitations. First, this method involves a long-term commitment of time and manpower, probably for at least five to ten or more years. This is essential to insure a diversity of observations at a variety of flows. Long study periods are also required to enable the researcher to follow individual year classes of fishes through their life cycle (from fry to adult) which commonly requires three to five years. Because of the long-term nature of such studies, the researcher must remain aware of, and try to account for, changes in the watershed (logging, grazing, other development) and management policies (fish stocking changes, fishing regulations) that may also affect fish populations. Further, long-term studies can generate enormous amounts of complex hydrologic and fisheries information (if multiple species and life stages are considered), which can prove difficult to compile in a consistent, meaningful, and defensible manner. Consequently, this approach has been applied to only a few waters.

Due to their intensive data requirements, long-term, empirical IFM evaluation studies are relatively rare. They are advantageous because they provide flow recommendations based on direct observations of fish population response to a flow regime under "natural" conditions. The adequacy of IFM flow recommendations can then be critically evaluated, as Nelson (1980a, 1980b and 1980c) and Anderson and Nehring (1985) have done. Annear and Conder (1984) stressed the continued need for such studies:

> "The question of adequacy of any instream flow method for fisheries will only be resolved by long-term biological documentation - a component of all comparisons of instream flow methods that is noticeably missing. Until this issue is resolved, studies such as this one will continue to only hint at acceptable procedures for identifying realistic fishery needs for instream flow."

Evaluations of Montana's Wetted Perimeter Method

The adequacy of Montana's wetted perimeter inflection point method has been tested using all three of the above study approaches with generally good results. Based on our review of the literature, it appears to be the most thoroughly evaluated of the "habitat retention" IFM's.

Orth and Maughan (1982) compared the wetted perimeter, Tennant, and IFIM methods on a warmwater stream in Oklahoma. They found that all three methods produced similar, acceptable minimum flow recommendations for the low flow period. Randolph (1984) evaluated the wetted perimeter method in a small stream in southwestern Montana during a two-month period in late summer/early fall. Wild rainbow trout densities in three stream sections were enhanced to simulate "carrying capacity" by the relocation of wild fish from upstream areas. He concluded that the wetted perimeter inflection point method produced an accurate minimum flow recommendation for a section characterized by riffle-pool habitat, but it underestimated fish flow needs in riffle-run sections. Fish population response to reduced flows (emigration) appeared to be more closely related to riffle depth (total or longest, continuous top width having depth of 15 cm or more) than to changes in wetted perimeter. Hence, depth criteria may be violated before the wetted perimeter inflection point is reached in the relatively shallow riffle-run habitats of small streams.

Nelson (1980a and 1980b) compared minimum flow recommendations derived using the wetted perimeter, Tennant, and IFIM methods to long-term information on trout standing crop and flow in five reaches of four "blue ribbon" rivers in southwest Montana. With one exception, the empirical trout/flow data sets included information for 4-13 years. He concluded that inflection points on wetted perimeter-discharge curves for one riffle in each river provided acceptable flow recommendations. Recommendations based on composites of several transects through various habitat units (pools, runs, and riffles combined) were not as reliable because inflection points were less easily recognized. The Tennant method was found to be of some use in making minimum flow recommendations, but percentage of flow required appeared to vary between rivers. Finally, IFIM flow recommendations were inordinately low due to a number of problems, including the program's use of mid-depth velocity measurements, rather than the velocities near the stream bottom, to describe the water velocities used by fish. The CIFSG has since corrected this problem.

Loar et al. (1985a) observed population fluctuations of three age classes of rainbow trout in two Appalachian streams over a two-year period in relation to late summer low flows. They found that young-of-the-year rainbow trout preferred shallow riffle habitats, and flow-related population declines of these fish were related to reductions in riffle wetted perimeter.

Studies by Annear and Conder (1984) and Bietz et al. (1985) examined the consistency of the wetted perimeter recommendations for a number of streams by comparing them to recommendations derived from other methods or by converting them to percentages of the mean annual flow and comparing these to each other. These studies, while contributing to the advancement of the state-of-the-art, are not considered in this discussion because they do not address the adequacy of the wetted perimeter recommendations in maintaining the stream fisheries at acceptable levels.

Criteria for Selecting an IFM

A number of factors must be considered before selecting an appropriate IFM for a given situation. These include biological goals, geographic scope, administrative goals, time and manpower availability, biological and historical streamflow data availability, ability to monitor and enforce flow recommendations, and the type of decision-making process followed.

The geographic scope and the type of water allocation process involved are the primary considerations in selecting an appropriate IFM. Trihey and Stalnaker (1985) concluded that standard setting methods (such as the Tennant method and Montana's wetted perimeter inflection point method) are most appropriate for:

1. Protecting the instream flow resource.
2. State water plans.
3. State water allocation permits or reservations.
4. Identifying target flow for use during project feasibility studies.

They concluded that incremental methods (primarily IFIM) are most appropriate for:

1. Time series analysis to identify limiting flow conditions.
2. Fine tuning a resource maintenance objective (maximum utilization of available water).
3. Avoiding or minimizing flow-related impacts.
4. Comparing mitigation alternatives.

These recommendations carry substantial weight and are based on considerable experience; one of the authors (Dr. Stalnaker) has been the leader of the

CIFSG since its formation one decade ago.

The "standard setting" methods are most appropriate for basinwide water allocation because they can provide cost effective, simple, single, minimum flow values for a large number of streams with a minimal amount of time consuming negotiations. Simple, minimum flow recommendations facilitate water allocation processes and can be monitored and enforced with relative ease. Other advantages are that these methods require little or no long-term streamflow data and (at least in Montana) appear to provide reasonable minimum flow recommendations for streams and rivers alike.

The high time and manpower requirements and the nature of the decision-making process make IFIM an impractical tool for use in State water allocation programs. As pointed out by the developers of the method (Bovee 1982, Trihey and Stalnaker 1985), IFIM is not designed to set minimum flows. Rather, it is designed for negotiating flow regimes for specific project areas by quantifying flow-related habitat tradeoffs.

We contacted water resource administrators in fish and wildlife agencies in several western states and the provinces of Alberta and British Columbia in early 1986 to solicit their views regarding the use of the wetted perimeter inflection point method and to ascertain which IFM(s) they utilized. The results indicated that most states or provinces follow a hierarchical approach similar to that described by Loar and Sale (1981) or Trihey and Stalnaker (1985). That is, they employ a variety of IFM's (non-field, habitat retention, and incremental) in their programs depending upon the needs of a particular situation. The use of IFIM is usually restricted to significant water development projects or highly controversial allocation disputes.

Six of the eight agencies (Colorado, Washington, Minnesota, Wyoming, Idaho, and British Columbia) that responded indicated that they used some variation of the wetted perimeter method in some part of their instream flow program. California and Alberta do not use the wetted perimeter method. California currently has no basinwide allocation process analogous to Montana's water reservation system, so they are primarily concerned with new water development projects on which they place "conditions" (personal communication with Gary Smith, Fisheries Biologist, California Fish and Game). California requires project developers to fund and conduct IFIM studies, which the State then reviews. Alberta is currently developing a modification of the Tennant method to be used on a basinwide planning scale and uses IFIM on large water development projects.

MONTANA'S INSTREAM FLOW METHOD

An IFM that was compatible with the State's water reservation process - the only legal means for protecting instream flows in Montana after 1973 - was a major consideration when the MDFWP selected its primary method for making instream flow recommendations. Under the reservation process, the unappropriated waters in a basin are allocated among all competing uses, including municipal, agricultural and industrial as well as instream for the protection of fish and wildlife and water quality. When granted, the instream reservation becomes a part of the priority date system, with some future uses subject to, or junior to, the instream reservation. During some time periods, especially in water short years, junior consumptive users will have to comply with the terms of the reservation and cease withdrawing water when streamflows fall below the granted instream flows. Given this requirement, complex flow recommendations that vary by time period and by year are generally unsuitable because they confuse junior water users and exacerbate problems with compliance and policing. A single, year-round recommendation tends to minimize these problems, but such a recommendation may fail to fully satisfy the instream flow needs of all fish species and all of their life stages and functions. However, keeping the recommendations simple appears, in the long run, to be in the best interest of the resource because compliance and policing problems are minimized.

Under the reservation process, the Department has the responsibility for requesting instream flow protection for literally hundreds of streams. Due to the large number of streams involved, funding, manpower and time limitations also became an important consideration in the selection of an appropriate method.

Incompatibility with the reservation process eliminated many of the approximate 90 identified IFM's for use by the MDFWP in its instream flow program. Of the three broad categories of methods previously described, two were quickly relegated to a secondary role in deriving recommendations.

Office or non-field methods (Category 1) were judged less desirable because of the Department's contention that the recommendations would be more credible if they reflected stream-specific habitat and discharge relationships rather than a flow quantity derived solely from the historic flow record. Furthermore, the lack of sufficient historic flow data for the vast majority of Montana's streams precluded the use of virtually all office methods. In addition, the consensus in the literature is that this category should be confined to deriving preliminary or reconnaissance grade recommendations (Stalnaker and Arnette 1976), thus limiting their suitability for Montana's reservation program.

Methods that apply species- and life stage-specific habitat criteria in evaluating the condition of the stream environment at various flows (Category 3) proved to be incompatible with the basic goal of the Department's instream flow program, which is to set flow recommendations at a level that will sustain existing fishery resources. Category 3 methods, of which the IFIM is the best known and most commonly applied example, were designed to be used in negotiating flows rather than setting minimum standards. This is a costly, complex and time consuming analysis that has limited application in the water reservation process.

Those methods that examine various components of a stream's hydraulic characteristics at various flows for the purpose of developing generalized habitat-discharge relationships are included in Category 2. The flow recommendations would not, in most cases, be based on detailed evaluations of the habitat requirements of specific fish species or life stages. The simplified prediction techniques that this group uses in evaluating the condition of the stream environment reduce the field data requirements to the point where dollar costs, manpower needs and time expended are reasonable. The outcome of the analysis is a minimum flow standard that is intended to fully protect some aspect of the stream resource. These methods are most appropriate when instream protection is requested for a large number of streams, as occurs in state water allocation programs (Trihey and Stalnaker 1985).

The MDFWP was, therefore, limited to selecting a method from Category 2. The method chosen was the wetted perimeter inflection point method. A brief description of the method, its assumptions and data needs follows.

Wetted Perimeter Inflection Point Method

This method focuses on the previously discussed assumption that the food supply can be a major factor influencing a stream's carrying capacity during the non-winter months. The principal food of many of the juvenile and adult game fish inhabiting the streams of Montana is aquatic invertebrates, which are produced primarily in stream riffle areas. The method assumes that the game fish carrying capacity is proportional to food production, which in turn is related to the amount of wetted perimeter in riffles.

Wetted perimeter is the distance along the bottom and sides of a channel cross-section in contact with water (Figure 4). As the flow in a stream channel increases, the wetted perimeter also increases, but the rate of gain of wetted perimeter is not constant throughout the entire range of flows.

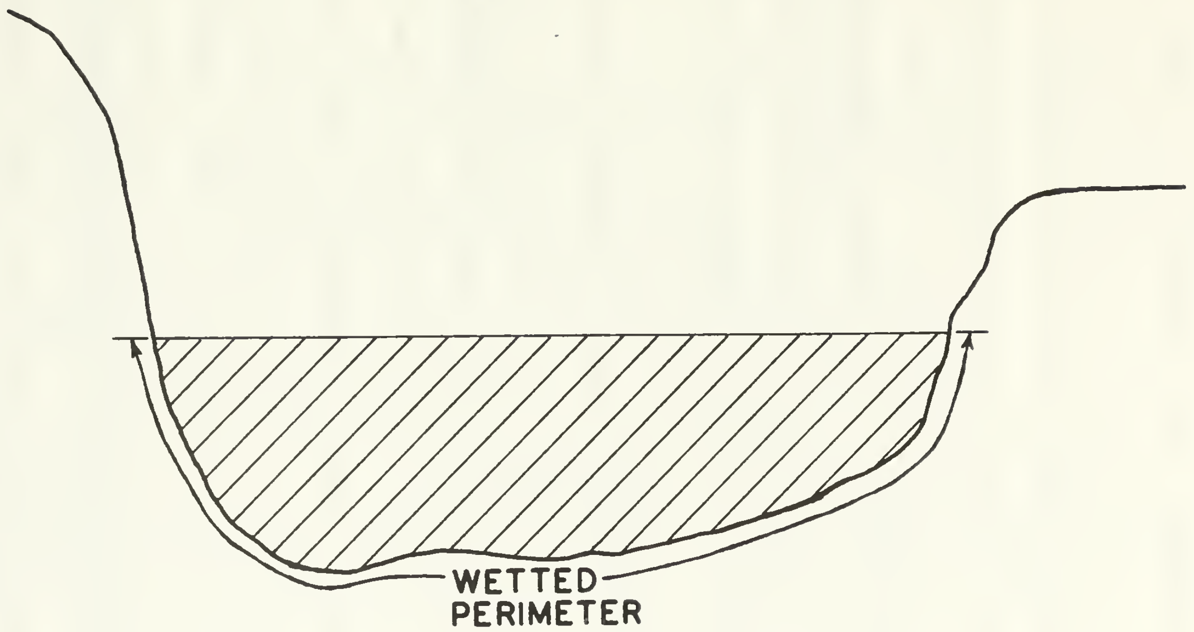

Figure 4. The wetted perimeter in a channel cross-section.

The plot of wetted perimeter versus flow for stream riffle cross-sections generally, but not always, shows two points, referred to as break or inflection points, where the rate of increase of wetted perimeter changes. In the example (Figure 5), these inflection points occur at approximate flows of 8 and 12 cfs. Below the lower inflection point, the flow is spreading out horizontally across the stream bottom, causing the wetted perimeter to increase rapidly for very small increases in flow. A point is eventually reached (at the lower inflection point) where the water starts to move up the sides of the active channel and the rate of increase of wetted perimeter begins to decline. At the upper inflection point, the stream is approaching its maximum width and begins to move up the banks as flow increases. Large increases in flow beyond the upper inflection point cause only small increases in wetted perimeter. Flow levels at these inflection points are depicted in Figure 6.

The area available for food production is considered near optimal at the upper inflection point because almost all of the available riffle area is wetted. At flows below the upper inflection point, the stream begins to pull away from the riffle bottom until, at the lower inflection point, the rate of loss of wetted bottom begins to rapidly accelerate. Once flows are reduced below the lower inflection point, the riffle bottom is being exposed at an even greater rate and the area available for food production greatly diminishes. The method is intended to establish a threshold below which a stream's food producing capacity begins to decline (upper inflection point) and a threshold at which the loss becomes unacceptable (lower inflection point).

While this inflection point concept focuses on food production, there are indications that wetted perimeter relates to other factors that influence a

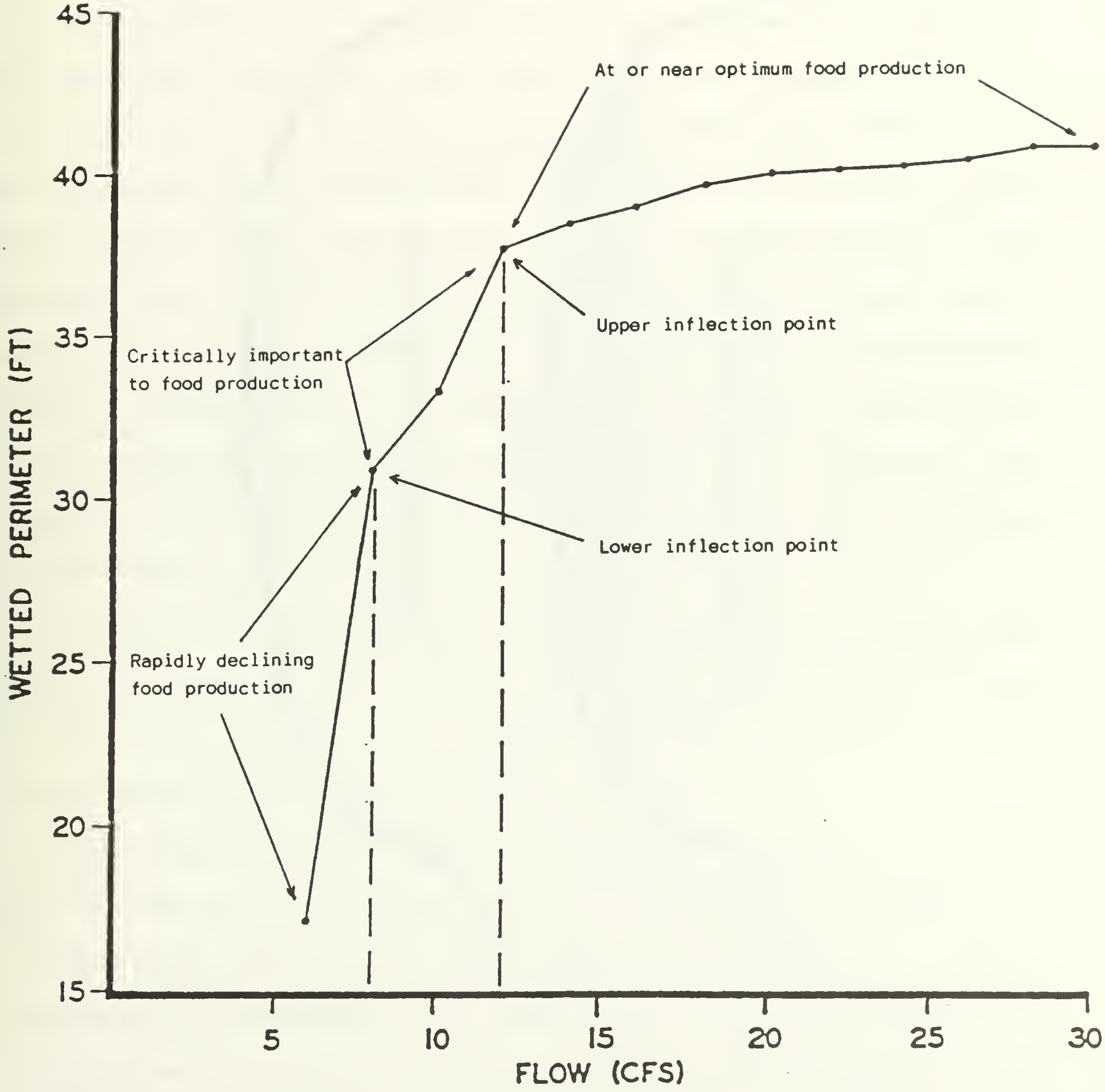

Figure 5. An example of a relationship between wetted perimeter and flow for a stream riffle cross-section showing upper and lower inflection points.

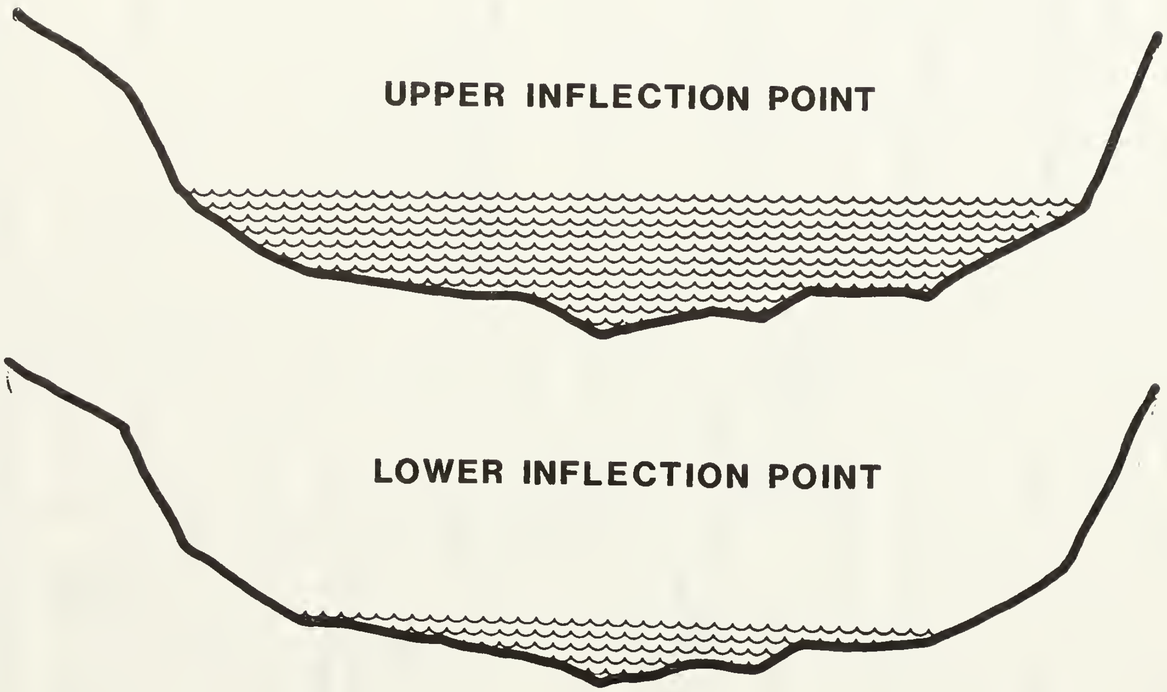

Figure 6. A diagrammatic representation of the flow at the upper and lower inflection points in a stream cross-section.

stream's carrying capacity. One such factor is cover (or shelter), a well recognized component of fish habitat.

In the headwater streams of Montana, overhanging or submerged bank vegetation and undercut banks are important components of cover. The wetted perimeter-flow relationship for a stream channel is, in some cases, similar to the relationship between bank cover and flow. Flows exceeding the upper inflection point are considered to provide near optimal bank cover. At the upper inflection point, the water begins to pull away from the banks, decreasing the amount of bank cover associated with water. At flows below the lower inflection point, the water is sufficiently removed from the bank cover to severely reduce its value as fish shelter. Support for this relationship is provided by Randolph (1984), who found a high correlation between riffle wetted perimeter at various flows and the total area of overhanging bank vegetation (r = 0.88-1.00) and undercut banks (r = 0.84-0.97) for three study sections in a small Montana stream.

In addition to producing food, riffles also are used by many game fish species for spawning and the rearing of their young (Sando 1981 and Loar et al. 1985a). Thus, the protection of riffles insures that the habitat required for these critical life functions is also protected.

Another important consideration that supports the keying of recommendations to riffles is the fact that riffles are the area of a stream most affected by flow reductions (Bovee 1974, Nelson 1977 and Loar et al. 1985a). By providing a recommendation that wets a large portion of the available riffle area, we are, at the same time, protecting both runs and pools - areas where adult fish normally reside.

The wetted perimeter inflection point method provides a range of flows (between the lower and upper inflection points) from which a single instream flow recommendation is selected. Flows below the lower inflection point are judged undesirable based on their probable impacts on food production, bank cover, and spawning and rearing habitats. Flows exceeding the upper inflection point are considered to provide near optimal conditions for fish. The upper and lower inflection points are believed to bracket those flows needed to maintain the high and low levels of aquatic habitat potential. These flow levels are defined as follows:

1. High Level of Aquatic Habitat Potential - That flow regime which will consistently produce abundant, healthy and thriving aquatic populations. In the case of game fish species, these flows would produce abundant game fish populations capable of sustaining a good to excellent sport fishery for the size of stream involved. For rare, threatened or endangered species, flows to accomplish the high level of aquatic habitat maintenance would: 1) provide the high population levels needed to ensure the continued existence of that species, or 2) provide the flow levels above those which would adversely affect the species.
2. Low Level of Aquatic Habitat Potential - Flows to accomplish a low level of aquatic habitat maintenance would provide for only a low population of the species present. In the case of game fish species, a poor sport fishery could still be provided. For rare, threatened or endangered species, their populations would exist at low or marginal levels. In some cases, this flow level would not be sufficient to maintain certain species.

The final flow recommendation is generally selected from this range of flows by a consensus of the biologists who collected and analyzed all relevant field data for the stream of interest. The biologists' rating of the stream resource forms the basis for the flow selection process. Factors considered in the evaluation include: (1) the level of recreational use, (2) the existing level of environmental degradation, (3) water availability and (4) the magnitude and composition of existing fish populations. Fish population information, which is essential for all streams, is a major consideration. A marginal or poor fishery would likely justify a flow recommendation at or near the lower inflection point unless other considerations, such as the presence of species of "special concern" (arctic grayling and cutthroat trout, for example) warrant a higher flow. In general, streams with significant resident fish populations, those providing crucial spawning and/or rearing habitats for migratory populations, and those supporting significant populations of species of "special concern" should be considered for recommendations at or near the upper inflection point.

Other candidates for upper inflection point recommendations are streams that have the capacity to provide outstanding fisheries, but are prevented from reaching their potential due to stream dewatering. The flow at the upper inflection point would provide a goal to strive for should the means become available to improve streamflows through such mechanisms as water storage projects or the purchase of irrigation rights. Streams that are subjected to other forms of environmental degradation, such as mining pollution, and which have the potential to support significant fisheries if reclaimed, are additional candidates for upper inflection point recommendations.

The process of deriving the flow recommendation for the low flow period thus combines a field method (wetted perimeter inflection point method) with a thorough evaluation by field biologists of the existing stream resource.

Brief Description of the Wetted Perimeter (WETP) Computer Program and Data Needs

The wetted perimeter-flow relationship for a stream of interest is derived using a wetted perimeter predictive (WETP) computer program developed in 1980 for the MDFWP.

Two pieces of information - the cross-sectional profile and stage-discharge rating curve - are required for each riffle cross-section as input into the WETP program. These data are obtained in the field using standard surveying procedures.

The stage-discharge rating curve describes the relationship between the height of the water surface (the stage) in the riffle cross-section and the magnitude of the flow (discharge) through the cross-section. This rating curve, when coupled with the cross-sectional profile, is all that is needed to compute the riffle wetted perimeter at most flows of interest.

The WETP program requires at least two sets of stage measurements taken at different known flows to develop the stage-discharge rating curve. However, the use of three sets of stage-discharge data collected at a high, intermediate and low flow is recommended. The three measurements are made when runoff is receding (high flow), near the end of runoff (intermediate flow) and during late summer-early fall (low flow). The high flow should be considerably less than the bankfull flow, while the low flow should approximate the lowest flow that normally occurs during the summer-fall season. Although the WETP program will run using only two sets of stage-discharge data, this practice is not recommended since substantial "two-point" error can result. However, when only two data sets are obtainable, the higher discharge should be at least twice as high as the lower discharge.

The channel profile also has to be measured for each cross-section. Unlike the measurements of water surface elevation, this has to be done only once. It is best to measure profiles at the lowest calibration flow when wading is easiest.

The wetted perimeter method is applied solely to riffles. Cross-sections can be established in a single riffle or in a number of different riffles. Cross-sections should describe the typical riffle habitat within the stream reach being studied. At least three and preferably five riffle cross-sections should be used in the analysis. The computed wetted perimeters for all riffle cross-sections at each flow of interest are averaged and the recommendation derived from the wetted perimeter-flow relationship for the composite of all riffle cross-sections.

An in-depth description of the WETP computer program and data collection procedures is provided in a publication titled "Guidelines for Using the Wetted Perimeter (WETP) Computer Program of the Montana Department of Fish, Wildlife and Parks" (Nelson 1984a).

MONTANA'S WETTED PERIMETER METHOD - FINAL CONSIDERATIONS

The wetted perimeter method is intended to quantify the flow needs of fish during the non-winter period from approximately April through October, excluding the high flow, or snow runoff, months of May, June and July when about 75% of a stream's annual water yield passes through the system (Figure 1). Flow recommendations for the high flow period should be based on those flows deemed necessary for flushing the annual accumulation of bottom sediments and maintaining the existing channel morphology.

A stream's annual high flow characteristics are generally accepted as being the major force in the establishment and maintenance of channel form. It is the high spring flows that determine the shape of the channel rather than the average or low flows.

The major functions of the high flows in the maintenance of channel form are bedload movement and sediment transport. It is the movement of the bed and bank material and subsequent deposition which forms the mid-channel bars and, subsequently, the islands. High flows are capable of covering already established bars with finer material, which leads successively to vegetated islands. Increased discharge associated with spring runoff also results in a flushing action which removes deposited sediments and maintains suitable gravel conditions for aquatic insect production, fish spawning and egg incubation.

Reducing the high spring flows beyond the point where the major amount of bedload and sediment is transported would interrupt the ongoing channel processes and change the existing channel form and bottom surfaces. A significantly altered channel configuration would affect both the abundance and species composition of the present aquatic populations by altering the existing habitat types.

Montana's high flow method, termed the dominant discharge/channel morphology concept (Montana Dept. of Fish and Game 1979), requires at least 10 years of continuous USGS gage records to derive recommendations and, consequently, cannot be applied to most streams. Recommendations from the wetted perimeter inflection point method do not satisfy flushing or channel maintenance requirements. Because most water users, particularly irrigators, are unable to divert a significant portion of the runoff flows and, therefore, are incapable of materially impacting the high flow functions of bedload movement and sediment transport, the need for high flow recommendations may be unnecessary in most cases. Therefore, extending the wetted perimeter recommendations through the high flow period - a common practice of the MDFWP - should not jeopardize the maintenance of adequate high flows for most streams. Furthermore, a Montana law that limits the granted instream flows for gaged streams to no more than 50% of the mean flow, prevents the MDFWP from requesting flushing and channel maintenance flows for these waters.

As discussed in an earlier section, the protection of natural flow levels during the critical winter months is justified if the goal is to maintain fish populations at their existing levels. As a guideline, the winter recommendation should not be less than the base flow, which is defined as the lowest mean monthly flow during the winter months. Because the vast majority of Montana's waters are ungaged, winter base flows are unquantified for most streams. Past work by the MDFWP has shown that the upper inflection point recommendations of the wetted perimeter method typically exceed base flows (Leathe et al. 1985). Winter flows would, therefore, be protected if upper inflection point recommendations were extended through the winter period. This is a common practice of the MDFWP when recommending flows. Lower inflection point recommendations are normally inadequate for protecting winter base flows.

Regardless of the method used to quantify instream flows, there will be some time periods, especially during drought years, when the recommendations exceed the available flows. Only when the recommendations equal the historic low flows would they never exceed the available water supply. However, such recommendations would devastate a stream fishery if maintained for any length of time and are analogous to asking a farmer to produce crops using only the amount of water available during the worst drought year on record.

Leathe and Enk (1985) evaluated the amount of time the wetted perimeter recommendations for five gaged, mountain streams in Montana's Swan River drainage exceeded the available streamflows. Year-round, upper inflection point recommendations were found to exceed daily streamflows from 24 to 64% of the time, depending on which of the five streams was evaluated. On the average, recommendations exceeded the available daily flows 41% of the time and, conversely, were less than the daily flows 59% of the time. In other words, excess water would be available for other uses 59% of the time, on the average. Unpublished data for a number of the larger rivers in southwest Montana showed that the wetted perimeter recommendations generally fell within the 60th to 90th percentile range of flows, meaning that the available daily streamflows, even with existing depletions, will still exceed the recommendations from 60 to 90% of the time.

The wetted perimeter inflection point method has primarily been applied in Montana to coldwater trout streams east and west of the Continental Divide. Results of validation studies in Montana support the use of this method in deriving minimum flow recommendations for these waters (Nelson 1980a, 1980b and 1980c and Randolph 1984). The logic behind the method should apply to warmwater streams as well. However, no biological studies have been conducted in Montana to confirm the reliability of warmwater recommendations, although a warmwater evaluation in Oklahoma supported the use of wetted perimeter (Orth and Maughan 1982).

The wetted perimeter method is unsuitable in certain situations. The method is designed for use on stream reaches in which the flow is confined to a single channel, although the application to side channels off of main river channels is a commonly used approach for deriving recommendations for those rivers in which side channels are crucial to the well-being of certain species. When the flow is distributed among many channels, cross-sections through these braided reaches are very difficult to model hydraulically, making most computer models, including WETP, unworkable in this situation. Waters having little or no riffle development, such as cascading mountain streams that plunge from pool to pool and some low gradient, prairie streams, are another exception, as are spring creeks. The stable, year-round flows that characterize spring creeks prevent the collection of field data at a high, medium and low flow - information needed to calibrate the WETP computer program.

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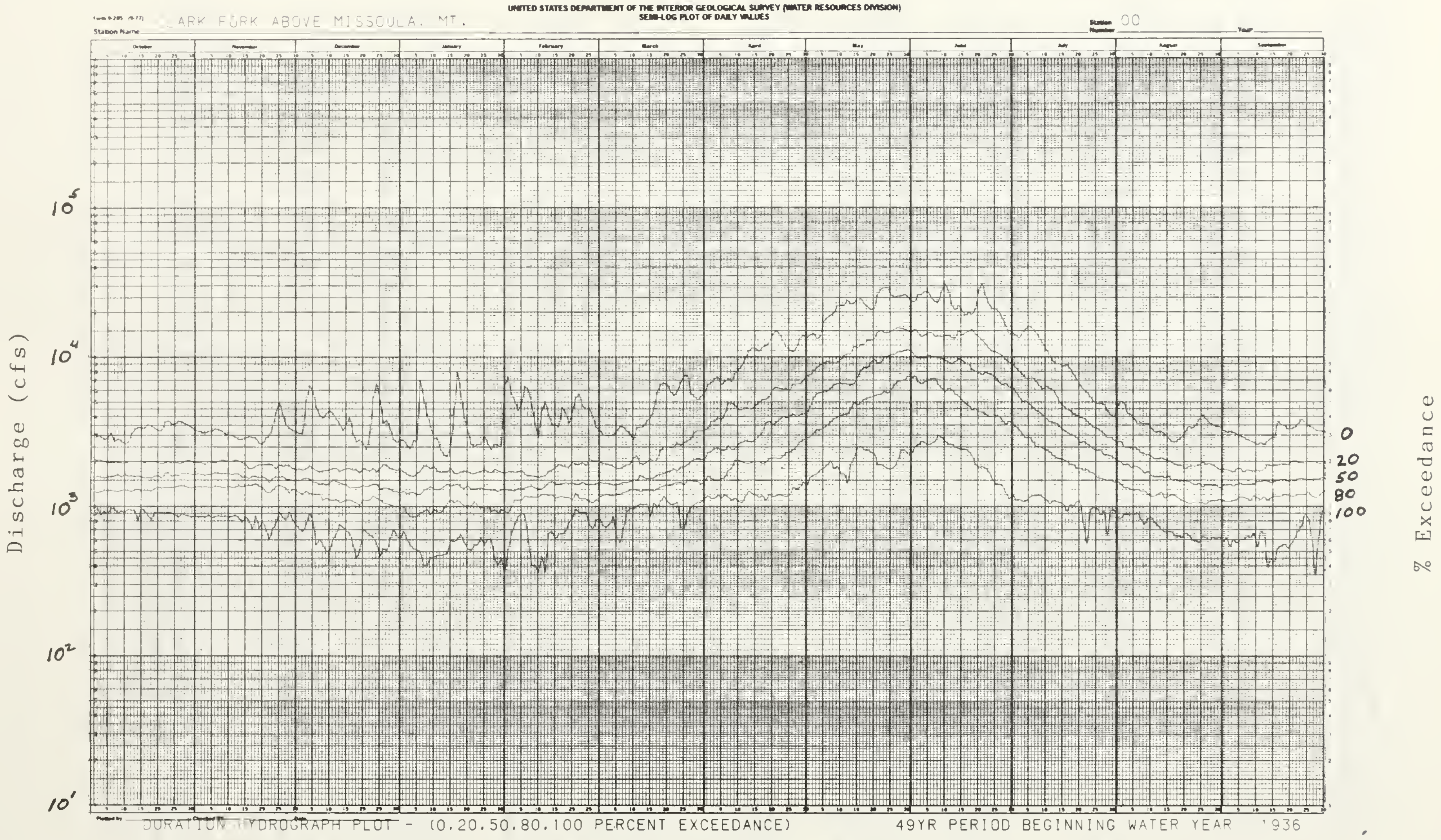


Addendum D. Flow duration hydrograph of Clark Fork River showing 0, 20, 50, 80 and 100 percent exceedence levels.

TOTAL LIVESTOCK AND PRODUCTS[1]
(Thousands of Dollars)

		ACTUAL			ADJUSTED (1984 $)	
County	Year	By County	Total	Index[2]	By County	Total
Deerlodge	1970	1,474			3,173	
Granite		3,710	8,839	325	8,002	19,065
Powell		3,655			7,884	
Deerlodge	1971	1,280			2,778	
Granite		4,581	11,098	323	9,942	24,086
Powell		5,237			11,366	
Deerlodge	1972	1,114			2,093	
Granite		5,734	14,203	372	10,805	26,764
Powell		7,355			13,860	
Deerlodge	1973	970			1,355	
Granite		6,939	17,312	502	9,690	24,175
Powell		9,403			13,130	
Deerlodge	1974	934			1,442	
Granite		3,835	10,496	454	5,921	16,206
Powell		5,727			8,843	
Deerlodge	1975	297			439	
Granite		4,271	12,473	474	6,316	18,446
Powell		7,905			11,691	
Deerlodge	1976	466			674	
Granite		4,404	11,191	485	6,365	16,175
Powell		6,321			9,136	
Deerlodge	1977	515			751	
Granite		4,578	11,561	481	6,672	16,849
Powell		6,468			9,426	
Deerlodge	1978	$2,638			3,108	
Granite		$8,639	$21,567	595	10,178	25,409
Powell		$10,290			12,123	
Deerlodge	1979	$3,181			3,150	
Granite		$10,871	$26,954	708	10,764	26,688
Powell		$12,902			12,774	
Deerlodge	1980	$2,944			2,987	
Granite		$10,057	$24,946	691	10,203	25,308
Powell		$11,945			12,118	
Deerlodge	1981	$2,500			2,547	
Granite		$8,553	$21,209	688	8,715	21,610
Powell		$10,156			10,348	
Deerlodge	1982	$2,517			2,535	
Granite		$8,445	$21,229	696	8,506	21,382
Powell		$10,267			10,341	
Deerlodge	1983	$2,572			2,655	
Granite		$8,655	$21,635	679	8,935	22,335
Powell		$10,408			10,745	
Deerlodge	1984	$3,048			3,048	
Granite		$10,645	$26,027	701	10,645	26,027
Powell		$12,334			12,334	

1. Source: Regional Economic Measurement Division, Bureau of Economic Analysis, Department of Commerce, Washington, D.C.
2. 'Business Statistics'(1973,1982), Bureau of Economic Analysis, Department of Commerce. Washington, D.C.

Addendum E-1. Total cash revenue from livestock and livestock products in Deerlodge, Granite and Powell counties, 1970-1984.

TOTAL CROP INCOME[1]
(Thousands of Dollars)

County	Year	ACTUAL By County	ACTUAL Total	Index[2]	ADJUSTED (1984 $) By County	ADJUSTED (1984 $) Total
Deerlodge	1970	306	1,533	225	813	4,074
Granite		307			816	
Powell		920			2,445	
Deerlodge	1971	249	1,629	242	615	4,025
Granite		382			944	
Powell		998			2,466	
Deerlodge	1972	327	2,298	257	761	5,347
Granite		576			1,340	
Powell		1,395			3,246	
Deerlodge	1973	506	3,713	394	768	5,636
Granite		915			1,389	
Powell		2,292			3,479	
Deerlodge	1974	789	4,740	504	936	5,624
Granite		1,271			1,508	
Powell		2,680			3,180	
Deerlodge	1975	390	3,871	452	516	5,121
Granite		1,146			1,516	
Powell		2,335			3,089	
Deerlodge	1976	446	4,956	443	602	6,690
Granite		1,039			1,403	
Powell		3,471			4,685	
Deerlodge	1977	858	5,231	433	1,185	7,225
Granite		1,469			2,029	
Powell		2,904			4,011	
Deerlodge	1978	154	2,503	456	202	3,282
Granite		784			1,028	
Powell		1,565			2,052	
Deerlodge	1979	143	2,621	501	171	3,129
Granite		838			1,000	
Powell		1,640			1,958	
Deerlodge	1980	160	2,916	539	178	3,235
Granite		927			1,028	
Powell		1,829			2,029	
Deerlodge	1981	190	3,407	580	196	3,513
Granite		1,067			1,100	
Powell		2,150			2,217	
Deerlodge	1982	209	3,290	524	239	3,756
Granite		917			1,047	
Powell		2,164			2,470	
Deerlodge	1983	196	3,296	551	213	3,577
Granite		973			1,056	
Powell		2,127			2,308	
Deerlodge	1984	160	3,279	598	160	3,279
Granite		1,137			1,137	
Powell		1,982			1,982	

1. Source: Regional Economic Measurement Division, Bureau of Economic Analysis, Department of Commerce, Washington, D.C.
2. 'Business Statistics'(1979,1982), Bureau of Economic Analysis, Department of Commerce. Washington, D.C.

Addendum E-2. Total cash revenue from crops in Deerlodge, Granite and Powell counties 1970-1984.

RECEIVED
APR
FISHERIES DIV.

DEPARTMENT OF NATURAL RESOURCES
AND CONSERVATION
HELENA FIELD OFFICE

TED SCHWINDEN, GOVERNOR

28 SOUTH RODNEY
CAPITOL STATION

STATE OF MONTANA

(406) 444-6695

HELENA, MONTANA 59620

APR

FISHERIES DIV.

April 24, 1985

Mr. Larry Peterman
Montana Department of Fish, Wildlife & Parks
1420 East Sixth Avenue
Helena, MT 59620

Re: Objection to Application for Beneficial Water Use Permit
No. 59095-76G (Keith W. Edge)

Dear Mr. Peterman:

The Department of Natural Resources and Conservation (DNRC) issues Water Use Permits based on the criteria set forth in Section 85-2-311 MCA (copy enclosed). It appears all the criteria of subsection (1) have been met by the applicants.

Your objection does not indicate a specific water right that the proposed diversion will adversely affect. A search of DNRC records indicated the DFWP has no claimed or permitted water rights from the Clark Fork River. Because the DFWP has no water rights from the Clark Fork to be affected, I am ruling the objection invalid.

If you do not agree with my decision, or if there is something I have overlooked, please inform me, in writing, within fifteen (15) days of the date of this letter. If no response is made, a Provisional Permit will be issued from the above-referenced application.

Sincerely,

T. J. Reynolds

T. J. Reynolds, Area Office Supervisor
Water Rights - Helena Field Office

TJR:es

C: Keith W. Edge
P. O. Box 302
Deer Lodge, MT 59722

Addendum F-1. Example of invalid objection ruling by DNRC.

DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION
WATER RIGHTS BUREAU/MISSOULA

TED SCHWINDEN GOVERNOR

2101 BOW STREET
PO BOX 5004

STATE OF MONTANA

(406) 721-4284

MISSOULA MONTANA 59806

July 31, 1985

RECEIVED
AUG [illegible] 1985
FISHERIES DIV.

Montana Dept. of Fish, Wildlife & Parks
Larry Peterman
1420 E. 6th Avenue
Helena, Montana 59620

RE: Application for Beneficial Water Use Permit, #57857-76M, Green Acres

Dear Mr. Peterman:

The statutory criteria for issuance of a water right permit appropriating water at a rate other than 5.5 cfs, 4,000 acre feet per year and consumptively used are:

a) there are unappropriated water in source of supply
b) water rights of prior appropriators will not be adversely affected
c) proposed means of diversion, construction and operation are adequate
d) proposed use is a beneficial use
e) proposed use will not adversely interfere with other permitted or reserved uses.

The Department of Fish, Wildlife & Parks objection to the above stated permit does not address any of these points. If issuance of this permit exacerbate the water quality and fisheries habitat problems in the Clark Fork River, I regret there is nothing that we can do about it. If on the other hand the Department of Fish, Wildlife & Parks had or develops an instream reservation for this section of the river, then under condition "e", stated above, the Department of Natural Resources and Conservation could deny this permit issuance.

Since the Department of Fish, Wildlife & Parks does not have a water right affected by the issuance of this permit and since the criteria for issuance can be met, the Department of Natural Resources and Conservation proposes to issue the above stated permit.

Section 85-2-310, MCA, 1985, provides that a person aggrieved by an opinion of this Department is entitled to a hearing before the Department. A request for a hearing must be made within thirty days of this letters mailing.

Sincerely,

Michael P McLane

MICHAEL P. McLANE
Field Manager
Missoula Field Office

MPM:sll
cc: Green Acres c/o Joe Pike

Addendum F-1. Example of invalid objection ruling by DNRC.

DEPARTMENT OF NATURAL RESOURCES
AND CONSERVATION
HELENA FIELD OFFICE

TED SCHWINDEN, GOVERNOR
STATE OF MONTANA
28 SOUTH RODNEY
CAPITOL STATION
HELENA, MONTANA 59620

September 11, 1985

RECEIVED
SEP 12 1985
FISHERIES DIV.

Mr. Larry G. Peterman
Montana Department of Fish, Wildlife & Parks
1420 East Sixth Avenue
Helena, MT 59620

RE: OBJECTION TO APPLICATION #59176 (CLIFFORD OR DORIS BENSON)

Dear Mr. Peterman:

I want to thank you for your letter dated September 6, 1985 dealing with the above-referenced application. I do understand your disagreement to us issuing Mr. Benson a Provisional Permit, but according to the Montana Water Use Act (Section 85-2-311), I do not see where we have much choice but to issue the permit to Mr. Benson. All permits are issued subject to existing rights which include those of Fish, Wildlife and Parks. Your objection and letter of disagreement are a matter of record.

For your information, I have ruled your objection invalid and Mr. Benson will be issued a Provisional Permit.

If you have any questions or if I may be of assistance, please feel free to contact me.

Sincerely,

T. J. Reynolds

T. J. Reynolds, Area Office Supervisor
Water Rights - Helena Field Office

TJR:es

Addendum F-2 (con't)

DEPARTMENT OF NATURAL RESOURCES
AND CONSERVATION
HELENA FIELD OFFICE

TED SCHWINDEN GOVERNOR

STATE OF MONTANA

(406) 444-6695

25 SOUTH RODNEY
CAPITOL STATION

HELENA, MONTANA 59620

August 23, 1985

Mr. Larry G. Peterman
Montana Department of Fish, Wildlife & Parks
1420 East Sixth Avenue
Helena, MT 59620

RE: OBJECTION TO APPLICATION #59176
(Clifford or Doris Benson)

Dear Larry:

The Department of Natural Resources and Conservation issues Provisional Permits on applications which have met the criterion of Section 85-2-311, MCA. It appears that your objection is based on subsections (1), (2), and (5), which deal with the availability of water and the proposed diversion's interference with prior appropriators' rights. Your objection claims an adverse effect will be caused by Mr. Benson's proposed diversion. The objection does not mention any claims, appropriations, or reservations that the Department of Fish, Wildlife and Parks has to protect the fish in this reach of the Clark Fork River.

I have searched our records and I have found no claims, appropriations, or reservations that relate to fish or wildlife use in this reach of the Clark Fork River. In the apparent absence of any water rights, in the area of affect, by the Department of Fish, Wildlife, and Parks, I am ruling the objection invalid.

If you do not agree with my decision, or if there is something I have overlooked, please inform me, in writing, within fifteen (15) days of the date of this letter. If no response is made, a Provisional Permit will be issued from the above-referenced application.

Sincerely,

T.J. Reynolds

T. J. Reynolds, Area Office Supervisor
Water Rights - Helena Field Office

TJR:es

C: Clifford Benson

Montana Department of Fish, Wildlife & Parks

1420 East Sixth Avenue
Helena, MT 59620

September 6, 1985

T. J. Reynolds
Water Rights Office
28 South Rodney
Capitol Station
Helena, MT 59620

RE: Water Permit Application #59176-S76G
Clifford Benson
Clark Fork River

Dear Mr. Reynolds:

The Montana Department of Fish, Wildlife and Parks (MDFWP) disagrees with the decision, as stated in your letter of August 23, to issue the above-referenced permit. Your decision is based on the conclusion that, because the MDFWP has no prior rights or reservations protecting the fish, wildlife and recreational resources, the concerns raised in our objection are invalid. While this action provides an expedient means for dismissing our objection, it does not address the fact that the upper Clark Fork, particularly in the vicinity of Deer Lodge, is subject to severe dewatering and, as a result, the public fishery is being jeopardized.

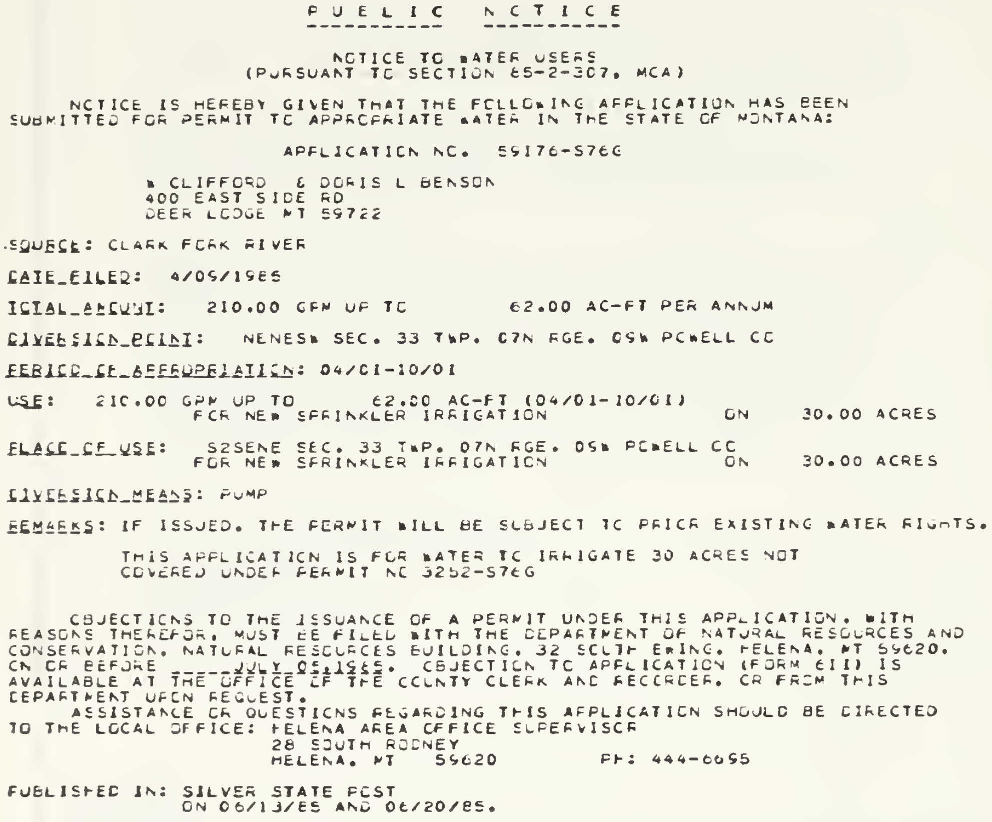
The severity of stream dewatering was quite evident during this summer's drought. Measurements made by the USGS on August 8 (see attachment) show a flow of 5.6 cfs in the approximate area where the diversion for this new permit will occur. A flow of this magnitude provides no more than a trickle of water through the deepest portions of the channel, and is incapable of sustaining fish for an extended period of time. The flows prior to August 8 were even lower and, conceivably, could have ceased entirely for brief periods. Clearly, the low flows of 1985 were detrimental to the public fishery. The occurrence of such low flow events will increase as long as water permits continue to be issued for the upper Clark Fork basin.

While the DNRC appears unable to address the impacts of its actions on a public resource, the impacts on the rights of existing water users should be of paramount concern. In light of the near total dewatering of portions of the upper Clark Fork this past summer, it is clear that the basin already has serious water availability problems. Obviously, it's unclear if there is in fact unappropriated waters available for new users throughout the irrigation season. A determination of what amounts are available, at what time periods and at what frequency must be completed before the potential impacts of additional depletions on existing water users can be quantified. Without this water availability information, the decision to issue or deny this permit cannot be made. If this analysis of water availability is not being done, a prudent approach that would protect the interests of prior appropriators as well as benefit the fishery, would be to restrict this and all future permits for the upper Clark Fork to the high flow or spring runoff period.

The MDFWP again requests that consideration be given to the concerns addressed in this letter. We also request that we be provided with the water availability data being used to support the issuance of this permit.

Sincerely,

Larry G. Peterman (FAN)



PUBLIC NOTICE

NOTICE TO WATER USERS
(PURSUANT TO SECTION 85-2-307, MCA)

NOTICE IS HEREBY GIVEN THAT THE FOLLOWING APPLICATION HAS BEEN SUBMITTED FOR PERMIT TO APPROPRIATE WATER IN THE STATE OF MONTANA:

APPLICATION NO. 59176-S76G

W CLIFFORD & DORIS L BENSON
400 EAST SIDE RD
DEER LODGE MT 59722

SOURCE: CLARK FORK RIVER

DATE_FILED: 4/09/1985

TOTAL_AMOUNT: 210.00 GPM UP TO 62.00 AC-FT PER ANNUM

DIVERSION_POINT: NENESW SEC. 33 TWP. 07N RGE. 09W POWELL CO

PERIOD_OF_APPROPRIATION: 04/01-10/01

USE: 210.00 GPM UP TO 62.00 AC-FT (04/01-10/01)
FOR NEW SPRINKLER IRRIGATION ON 30.00 ACRES

PLACE_OF_USE: S2SENE SEC. 33 TWP. 07N RGE. 09W POWELL CO
FOR NEW SPRINKLER IRRIGATION ON 30.00 ACRES

DIVERSION_MEANS: PUMP

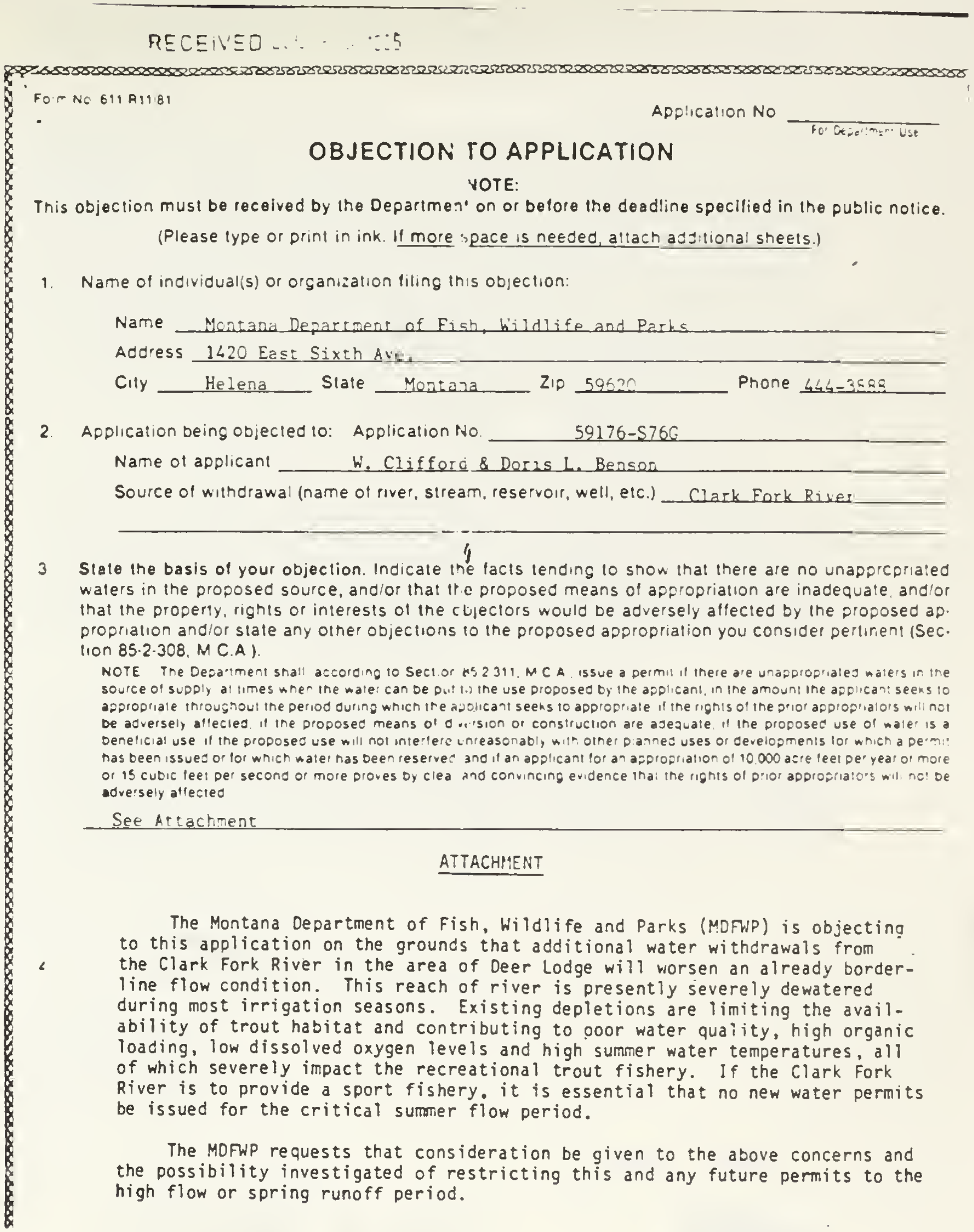
REMARKS: IF ISSUED, THE PERMIT WILL BE SUBJECT TO PRIOR EXISTING WATER RIGHTS.

THIS APPLICATION IS FOR WATER TO IRRIGATE 30 ACRES NOT COVERED UNDER PERMIT NO 3252-S76G

OBJECTIONS TO THE ISSUANCE OF A PERMIT UNDER THIS APPLICATION, WITH REASONS THEREFOR, MUST BE FILED WITH THE DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION, NATURAL RESOURCES BUILDING, 32 SOUTH EWING, HELENA, MT 59620, ON OR BEFORE _____JULY_05,1985. OBJECTION TO APPLICATION (FORM 611) IS AVAILABLE AT THE OFFICE OF THE COUNTY CLERK AND RECORDER, OR FROM THIS DEPARTMENT UPON REQUEST.

ASSISTANCE OR QUESTIONS REGARDING THIS APPLICATION SHOULD BE DIRECTED TO THE LOCAL OFFICE: HELENA AREA OFFICE SUPERVISOR
28 SOUTH RODNEY
HELENA, MT 59620 PH: 444-6695

PUBLISHED IN: SILVER STATE POST
ON 06/13/85 AND 06/20/85.



RECEIVED [illegible] 1985

Form No 611 R11/81

Application No ____
For Department Use

OBJECTION TO APPLICATION

NOTE:
This objection must be received by the Department on or before the deadline specified in the public notice.

(Please type or print in ink. If more space is needed, attach additional sheets.)

1. Name of individual(s) or organization filing this objection:

Name Montana Department of Fish, Wildlife and Parks
Address 1420 East Sixth Ave.
City Helena State Montana Zip 59620 Phone 444-3588

2. Application being objected to: Application No. 59176-S76G
Name of applicant W. Clifford & Doris L. Benson
Source of withdrawal (name of river, stream, reservoir, well, etc.) Clark Fork River

3. State the basis of your objection. Indicate the facts tending to show that there are no unappropriated waters in the proposed source, and/or that the proposed means of appropriation are inadequate, and/or that the property, rights or interests of the objectors would be adversely affected by the proposed appropriation and/or state any other objections to the proposed appropriation you consider pertinent (Section 85-2-308, M.C.A.).

NOTE The Department shall according to Section 85-2-311, M.C.A., issue a permit if there are unappropriated waters in the source of supply at times when the water can be put to the use proposed by the applicant, in the amount the applicant seeks to appropriate throughout the period during which the applicant seeks to appropriate, if the rights of the prior appropriators will not be adversely affected, if the proposed means of diversion or construction are adequate, if the proposed use of water is a beneficial use, if the proposed use will not interfere unreasonably with other planned uses or developments for which a permit has been issued or for which water has been reserved, and if an applicant for an appropriation of 10,000 acre feet per year or more or 15 cubic feet per second or more proves by clear and convincing evidence that the rights of prior appropriators will not be adversely affected

See Attachment

ATTACHMENT

The Montana Department of Fish, Wildlife and Parks (MDFWP) is objecting to this application on the grounds that additional water withdrawals from the Clark Fork River in the area of Deer Lodge will worsen an already borderline flow condition. This reach of river is presently severely dewatered during most irrigation seasons. Existing depletions are limiting the availability of trout habitat and contributing to poor water quality, high organic loading, low dissolved oxygen levels and high summer water temperatures, all of which severely impact the recreational trout fishery. If the Clark Fork River is to provide a sport fishery, it is essential that no new water permits be issued for the critical summer flow period.

The MDFWP requests that consideration be given to the above concerns and the possibility investigated of restricting this and any future permits to the high flow or spring runoff period.

Addendum F-2. Example of events leading to lack of standing in DFWP objection to water use permit application on Clark Fork River.

Addendum G

Irrigated and Non-irrigated Cropland, (acres) in Deerlodge, Granite and Powell Counties, 1970-1985.

	Irrigated	Non-Irrigated
	1970	
Deerlodge	15,400	1,100
Granite	32,800	2,600
Powell	51,300	13,900
	99,500	17,600
	1971	
Deerlodge	13,760	800
Granite	34,300	3,300
Powell	49,390	13,400
	97,450	17,500
	1972	
Deerlodge	13,330	800
Granite	39,200	1,500
Powell	47,030	1,200
	99,560	3,500
	1973	
Deerlodge	13,650	700
Granite	36,700	1,300
Powell	63,300	8,900
	113,650	10,900

1974

Deerlodge	12,120	2,000
Granite	40,000	1,400
Powell	49,260	9,000
	101,380	12,400

1975

Deerlodge	11,920	600
Granite	35,800	4,000
Powell	64,320	7,800
	112,040	12,400

1976

Deerlodge	13,510	400
Granite	31,500	2,100
Powell	58,290	10,600
	103,300	13,100

1977

Deerlodge	13,475	800
Granite	29,900	2,200
Powell	41,390	26,000
	84,765	29,000

1978

Deerlodge	12,600	600
Granite	27,100	1,900
Powell	43.490	19,000
	83,190	21,500

1979

Deerlodge	13,450	600
Granite	27,000	1,800
Powell	41,500	13,000
	81,950	15,400

1980

Deerlodge	16,740	900
Granite	30,510	1,700
Powell	45,600	17,700
	92,850	20,300

1981

Deerlodge	15,940	1,100
Granite	31,600	2,400
Powell	50,900	11,100
	97,940	14,600

1982

Deerlodge	16,300	900
Granite	33,700	3,300
Powell	36,150	11,500
	86,150	15,700

1983

Deerlodge	12,700	900
Granite	30,900	1,900
Powell	47,000	12,200
	90,600	15,000

1984

Deerlodge	14,600	900
Granite	34,000	3,600
Powell	56,000	12,800
	104,600	17,300

1985

Deerlodge	13,700	700
Granite	31,600	2,500
Powell	50,000	9,400
	95,300	12,600

Source: Montana Crop and Livestock Reporting Service.

APPENDIX H

Contributors

The persons listed below were principal contributors to, and/or reviewers of, the contents of this application.

1. Stewart Allen, Ph.D., Economist, University of Idaho, Moscow, Idaho.
2. Loren Bahls, Supervisor, Water Quality Management Section, Water Quality Bureau, Department of Health and Environmental Sciences, Helena, Montana.
3. Stan Bradshaw, Attorney. Formerly Chief Counsel, DFWP, Helena, Montana.
4. Robert Brooks, Bio-economist, Fisher es Division, DFWP, Bozeman, Montana.
5. Joe Elliott, Ecological Consultant, 835 Eighth Avenue, Helena, Montana.
6. Pat Graham, Chief of Management, Fisheries Division, DFWP, Helena, Montana.
7. Wayne Hadley, Ph.D. Fish and Wildlife Biologist, Fisheries Division, DFWP, Deerlodge, Montana.
8. Steve Holnbeck, Hydrologist, Department of Natural Resources and Conservation, Helena, Montana.
9. Ken Knudson, Consulting Biologist. Formerly Administrative Assistant, Governor's Office, Helena, Montana.
10. Bob Lane, Chief Counsel, DFWP, Helena, Montana.
11. Steve Leathe, Fish and Wildlife Biologist, Fisheries Division, DFWP, Great Falls, Montana.
12. Fred Nelson, Instream Flow/Water Rights Specialist, Fisheries Division, DFWP, Bozeman, Montana.
13. Larry Peterman, Chief, Research and Special Projects Bureau, Fisheries Division, DFWP, Helena, Montana.
14. Donald Peters, Fish and Wildlife Biologist, DFWP, Fisheries Division, Missoula, Montana.
15. Glenn Phillips, Pollution Control Biologist, Fisheries Division, DFWP, Helena, Montana.

16. James Posewitz, Leader, Resource Assessment Unit, DFWP, Helena, Montana.

17. Liter Spence, Water Resources Supervisor, Fisheries Division, DFWP, Helena, Montana.

18. John Tubbs, Economist, Department of Natural Resources and Conservation, Helena, Montana.

19. Dennis Workman, Regional Fisheries Manager, Fisheries Division, DFWP, Missoula, Montana.

Appreciation is also expressed to the following persons who typed this application more than once, and met those numerous deadlines unfailingly:

1. Pam Hyatt, Word Processing Tech., Centralized Services Division, DFWP, Helena, Montana.

2. Susan Kirley, Assistant Division Secretary, Fisheries Division, DFWP, Helena, Montana.

3. Barbara Lloyd, Word Processing Operator, Centralized Services Division, DFWP, Helena, Montana.